



NEW DATINGS AND CONSIDERATIONS ON THE CHRONOLOGY OF UPPER PALAEOLITHIC SITES IN THE GREAT EURASIATIC PLAIN

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1. INTRODUCTION

The great loessic plain from the Atlantic coast to Siberia has been the object of a large range of research concerning the Upper Palaeolithic and provided a lot of radiometric data from open sites (HAESAERTS 1985, 1990b, SOFFER 1985, DESBROSSE and KOZLOWSKI 1988). However no coherent or satisfactory chronology is presently available for the loess and loam deposits. One of the reasons is the low reliability of most radiocarbon datings which can vary greatly from site to site, from level to level, depending on the nature and the quality of the dated material, the pretreatment, the quantity of carbon submitted to dating, the mode of dating and the sequence of the procedures in the ^{14}C laboratory. For example the famous sites of Willendorf in Austria and Kostienki in Russia are key-sites for the establishment of the continental chronostratigraphy covering the Upper Palaeolithic. Unfortunately the available data is unsatisfactory due to the paucity of dates from some layers in Willendorf II (KS 9, 6 and 3) or, on the contrary, to their apparent too large dispersion in Kostienki 1 (cultural layer I). Thus it is of fundamental importance to carry out new radiometric data with an optimal reliability from a selection of key-sites in the Eurasian area.

One of the main goal of the research project Sc-004 was to found a general chronostratigraphy for the loessic Eurasiatic plain over the last 50,000 years. In a direct connection, the chronology of the climatic variations should be recognized over the continent. Finally, the radiometric datings should contribute to understand better how

the modern man had spread all over the Eurasia.

The following paper presents some 66 new radiocarbon datings and discuss previous data from a choice of 9 Upper Palaeolithic sites in the great loessic plain. The selection of the sites Willendorf II, Schwallenbach and Grubgraben (Lower Austria), Dolni Vestonice (Czech Republic), Mitoc Malu Galben (Roumania), Cosautsi (Moldavian Republic), Kostienki (Central Russia), Kurtak and Afontova Gora (Yenisei Basin) was made on the basis of their common importance for climatic reconstructions (figure 1). All of these are key-sites for the understanding of human industries, cultures and migrations. They are characterized by important loess sequences with paleosols, both containing good organic material for radiometric datings and palaeo-environmental reconstructions.

2. THE DATING STRATEGY

Obtaining reliable radiocarbon datings implies having a strict control on some parameters like stratigraphy and quality of the samples. In this perspective special attention was paid to the following conditions.

A. The first step is the precise knowledge of the stratigraphic origin of the sample. For that reason a detailed study of the stratigraphy represents the starting point of our program from which the position of each sample for radiocarbon dating can be given accurately.

B. The choice of the material to be dated is equally important. We have systematically traced charcoal for as well as archaeologists (SOFFER 1985, KUZMIN and TANKERSLEY 1996) as radiocarbon specialists (MOOK and WATERBOLK 1985, LANTING and VAN DER PLICHT 1994) consider that

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such type of material does represent the best quality/C-content ratio and gives the most reliable results. Samples of well conserved wood have also been collected and their dating positively compared with the results from charcoal (Kurtak). It is nonetheless true that we have obtained some good data from bones, and we have had the occasion to test cross-datings between both types of material (see Willendorf II, KS 8). Admittedly the choice was most often reduced and, for example, no charcoal pieces were to be found in some sites like Grubgraben. Consequently, all datings from this site were made on bones.

The case of burnt bones was more dubious and we have provisionally discarded this material considering with MOOK and WATERBOLK (1985) that the collagen content of such remains was probably too much altered and subjected to various uncontrollable contaminations. This does not mean that some datings from burnt bones have to be rejected for a lot of results are proved to be accurate and sometimes to give older dates than unburnt bones (EVIN 1990, SVEZHENTSEV and POPOV 1993).

C. It is also of prime interest to have a good appreciation of the spatial distribution of the material inside the stratigraphical unit. Most often, charcoal and/or bones were concentrated and closely associated with remains of industry. Charcoal accumulations in hearths or derived from fire-places were systematically collected with the collaboration of the excavators (Mitoc, Cosautsi). The best scenario was encountered when bones and charcoal could be sampled for parallel datings (Willendorf, Cosautsi). However, in some horizons, the pieces of charcoal were dispersed in the sediment mass so that we had no other alternative but to collect such material very carefully with the sediment matrix. This operation was made exclusively on section or step-banket in order to have a permanent control of the stratigraphy.

Charcoal can be uncovered in natural conditions too, without artefact association, as for instance at Schwallenbach and Kurtak from where clusters of charcoal were extracted. This leads to both dating control of some climatic events and to palaeoenvironmental reconstructions.

D. In connection with the spatial distribution of the material, the method of collecting samples has to be adapted in a way

to acquire a maximal carbon mass for dating and to verify continuously the homogeneity of the sample. In this perspective charcoal has been preferentially taken out of a refreshed wall section of loess (Willendorf, Schwallenbach, Cosautsi, Kurtak) with the possibility to get into the sampled layer along small steps under stratigraphic control. In that manner it was possible to sample a significant part of an Aurignacian structure derived from a hearth in the site of Mitoc Malu Galben.

We have also worked on samples collected from excavation surfaces (Kostienki 14, cultural layer III) but this procedure may bring about less reliable results because nothing is easier than going down from a surface through successive loam or loess layers and collecting a mixed sample. Fortunately, the stratigraphical study of the sites helped us to reduce such a risk of mixage and we will see that the new results on charcoal are satisfactory.

When the charcoal pieces are all dispersed in the sediment it is worthwhile once again to sample from small banket or along a section wall in order to increase the number of the holds in the same stratigraphical unit (Mitoc, Schwallenbach).

E. Laboratory treatment. As pointed out by GOWLETT and HEDGES (1987), BOWMAN (1990), GEYH (1990) and many others, a lot of dates are distorted by the effect of contaminations. A basic task for us was then to take all possible steps handling when to achieve the maximal pureness of the material destined for datings, keeping in mind that a total eradication of the contaminants is practically deluding.

In this perspective various procedures were applied to the bone remains and to charcoal. Bones, after elimination of the spongy ones and selecting dense pieces, were submitted to minimal treatments, essentially cleaning and removing the sediment crust, rapid washing and eventually cutting out the cortex or the external layer.

The charcoal remains followed a sequence of operations aiming to wash out the sediment matrix, to eliminate all other objects and matter, rootlets and other contaminants, to reduce the amount of secondary carbonates and silicates, to identify the taxonomic origin of the charcoal and to select the best pieces for

the dating process. That sequence is exposed in the next chapter concerning the methods.

F. The identification of the charcoal pieces is necessary to control the homogeneity of the sample submitted to the dating. As a general rule, we have exclusively selected charcoal pieces from conifers, essentially spruce and pine, in order to lower the probability of mixing with eventual intrusive Holocene taxa. For instance, the *Quercus* pieces were discarded from the charcoal extracted from layer I of Kostienki 12 and only *Picea* pieces were reserved for dating.

G. The dating process - conventional or by accelerator mass spectrometry (AMS) - is essentially a function of the mass of charcoal collected and selected. Still, whenever it was possible, we have given the preference to the conventional dating method (LANTING and VAN DER PLICHT 1994). In fact, and despite the work of cleaning and selecting, it is almost impossible to ascertain that contaminants are totally absent. Now, we consider that pollution is strongly reduced in a well selected sample of good quality but, if an undetectable contaminant is present in a small sample dated by AMS, the importance of this pollution will be exacerbated in the AMS measurement. From this point of view, by raising the sample weight, one may hope to dilute the effect of contamination. As a general rule, a minimum weight of 2 g was achieved for dating charcoal but most often we exceeded 3 g. In the same spirit, for the AMS which can be achieved on very low weights (5-10 mg), we have attempted to reach some 100-150 mg for the reasons already exposed.

H. The choice of the laboratory. In spite of the raising concordance of results from different laboratories, we have observed some discrepancies in datings which, after BOWMAN (1990), could originate in the non identical procedures and experience. In order to suppress these kinds of possible differences and to standardize the pretreatment and measurement procedures the samples were dated at the Center of Isotope Research of the University of Groningen. Not only this laboratory has a long experience of dating the Upper Palaeolithic in Central Europe but it has the advantage of managing both conventional and AMS datings. The Groningen dates are coded as GrN (conventional) or GrA (AMS).

3. THE METHODS

3. 1. *Preparation of the material for radiocarbon datings*

It is necessary to recall that our objective is to have an adequate weight of datable matter (carbon, collagen, polypeptides) of known taxonomic origin and cleaned of a maximum of contaminants.

3. 1. 1. *Treatment of bone material (remains of bones and antlers)*

A minimal treatment was applied in order to preserve a maximum of collagen : scraping and dusting of the surfaces to eliminate remains of sedimentary crusts (clay, sand, loess) and rapid washing with demineralized water (bones from Grubgraben, antler from Mitoc).

The remains of bones taken from the cultural layer 9 of Willendorf II (and preserved in the Naturhistorisches Museum Wien) have been submitted to a special preparation because of the use of a preservative by the Museum of Vienna. Therefore the two selected bones showed a brownish external zone and a whitish center. We have had to peel the pieces in the hope of eliminating a maximum quantity of preservative.

3. 1. 2. *Treatment of charcoal*

The raw sedimentary samples were weight in order to calculate the content of charcoal. The operation was not done for charcoal pieces gathered separately. The sedimentary material was then dispersed with precaution in the water, a process allowing the flottation of the less mineralized charcoal pieces. This manipulation can provoke the splintering of certain delicate or cracked charcoal pieces but in general the debris, after a long taphonomic process in the loess, remained hard and sufficiently solid to resist to the various separation and cleaning treatments. When the sample presented concentrations of clay, it was useful to add some sodium pyrophosphate as dispersant. The mixture was then sieved in the water through successive 1 mm, 0,5 mm and 0,25 mm meshes. In the majority of cases, more than 75% of the charcoal remains were extracted with the first two sieves.

A first examination of the charcoal in the water was realized with the binocular in order to separate the charcoal from the remains of bones and molluscs, from various crystals, and from principal contaminants present in debris of roots, rootlets or mycelium. It was sometimes necessary to break certain pieces in order to extract the rootlets that went through them but when some traces of rootlet periderm remained on a charcoal this was taken out the batch reserved for radiometric dating.

Often it was realized that the charcoal were covered by a gangue of secondary carbonates that had to be eliminated for microscopic observation. HCl (5-10% according to the need) was then progressively added to a water bath containing charcoal in order to control the intensity of the reaction. Such a treatment often liberates fine charcoal particles that come from tissues sealed in the carbonated envelopp. This insignificant loss has to be accepted to obtain pieces that are cleaned and identifiable. Another type of mineralization is due to silicates which cristallize in the light of the wood cells. The charcoal was then treated progressively with 10% HF in order to limit the exothermic reaction. After washing with the acid (10% HCl) the charcoal was rinsed a long time in demineralized water. The charcoal cleaned in this manner was dried in an oven at 50° C for 24 h. Before the identifications, a new sorting of the material allowed removing the last remains of rootlets and of mycelium and putting to one side doubtful and contaminated charcoal pieces.

3. 1. 3. Identification of charcoal

Microscopic examinations have been done on fractures following the three anatomic plans in reflected light with the help of a darkfield episcopic microscope. Moreover complementary examinations have been done with a scanning electron microscope.

The identification of the carbonized pieces is supported on the one hand by the comparison with a reference collection of wood sections and of carbonized wood and on the other hand by the use of atlases and xylologic identification keys available for Western and Central Europe (notably GREGUSS 1955, 1959; SCHWEINGRUBER 1978, 1990) to which should be added a number of illustrated works in palaeobotany.

3. 2. Treatment in the Groningen laboratory

3. 2. 1. Bone material

The datings at Groningen were made on collagen extracted according to the method of LONGIN (1970, 1971) after a pretreatment with NaOH according to GURFINKEL (1987). This procedure was soft and progressive in order to keeping a maximum amount of slightly altered collagen (figure 2).

3. 2. 2. Charcoal

The basis of the procedure was the so-called AAA treatment exposed in the papers of MOOK and WATERBOLK (1985) and of VAN DER PLICHT (in press). An additionnal HF treatment was made when silicates remained in charcoal.

3. 3. Presentation of the dates

According to the standard procedure followed at all ¹⁴C laboratories, the ¹⁴C ages are reported in B.P. which implies correction for isotopic fractionation by means of ¹³C. These ages (in B.P.) have to be calibrated in order to obtain historical ages. However, calibration by means of dendrochronology is only possible from ca. 9000 BC to the present (STUIVER, LONG and KRA 1993). Calibration can not be applied to the largest part of the time-span covered by our dates (50-10,000 BP).

For the main sites concerned, combined tables show the already available data and the dates Sc-004. In order to facilitate comparisons and the evaluation of the reliability of the results from Willendorf and from Mitoc, graphs have been drawn with the distribution of dates in a stratigraphic order (graphs A). In each sedimentary unit they are regrouped in chronological order. In effect, the synthetic form of this graph does not permit the representation of the depths of the different excavation squares. This type of graph will help us in the selection of reliable dates and to discard distorted results. The selected data is represented in a second type of graphs (graphs B) which synthetizes the chronostratigraphical interpretation of the concerned sites.

4. RESULTS : THE DATINGS AND THE RADIOCARBON CHRONOLOGY OF THE SITES

4.1. Willendorf II

The sites of Willendorf II and Schwallenbach along the Danube (Wachau) as well as Grubgraben and Stratzing to the North of Krems were used for the establishment of a renewed reference sequence for the Upper Pleistocene of Central Europe. In this respect, the loess record of Willendorf II, on the Western slope of the Danube valley with its nine cultural layers (among which two Aurignacian and five Gravettian) was one of the main goal of the Sc-004 project.

At the present time, we have 36 dates for the Willendorf II site of which 26 are new (Sc-004 dates, table 1). The later number comprises 3 double control dates (duplo). A particular effort was made to date a maximum of cultural layers and sedimentary units. Thus, the cultural layers (Kulturschichte) 9, 8, 6, 5, 4 and 3 have given 18 dates while the sedimentary unit D has given 2 supplementary ones without it being possible to find the cultural layer KS 2. Amongst the dates Sc-004, 19 have been made on charcoal and 7 on bone remains.

The representation of the data on the graph A 1 (figure 3) put in evidence a serie of dates clearly separated toward the top and which have been rejected for various reasons. Therefore the date n° 13 (GrA-917 : 22,180) of the layer KS 8 comes from a collagen extract made for a palaeo-immunologic experiment and clearly badly adapted to the radiometric datings. The date n° 2 of the layer KS 5 on humus (GrN-11194 : 23,830) was discarded for contamination reasons (HAESAERTS 1990 a). Lastly, the date n° 10 (GrN-1287 : 30,530), supposedly attributed to KS 1, presents too weak a value with regard to other dates of the unit D and its stratigraphic origin is more than uncertain (HAESAERTS 1990 a).

Taken as a whole, the graph A 2 (figure 4) establishes a chronological basis for the sedimentary accumulation and the human occupations at Willendorf II. It is clear that the 4 dates of the unit D must be considered wholly given that the dispersion of the charcoal pieces in the deposit and the large sigma of the dates derived from ancient and

mineralized samples. It would appear to indicate a higher rate of sedimentation than that of unit C.

The layer KS 3 has given 3 dates of which the oldest (n° 27; GrN-17805 : 38,880) comes from a conventional measurement while the AMS n° 26 (GrA-896 : 37,930) is slightly younger. As we have observed several times, this difference could be attributed to an uncontrolled contamination despite all the care of the anthracological analysis. In comparison with these two values, the date n° 7 (GrN-11192 : 34,100) obtained on a sample collected by HAESAERTS in 1981 (1990 a) appears too young for the same reasons.

The totality of the results from the layer KS 4 is remarkably coherent (n° 6, GrN-1273 : 32,060; n° 5, H-249/1276 : 31,700 and n° 25, GrA-501 : 31,210) but with an AMS measurement a little younger in comparison to the two others. The double sigma cover each other even if abstraction from the date n° 5 is made.

Within the layer KS 5, the updating of the AMS n° 24 (GrA-218 : 27,270) is even more evident as it presents more than 3000 years difference with the following ones (n° 3, GrN-11193 : 30,500 and n° 4, H-246/231 : 32,000). Despite the overlapping of the double sigma, the date n° 24 must surely be discarded. Amongst the two others, the date n° 3 (GrN-11193 : 30,500) presents itself as the best integrated in the sedimentation sequence between C4 and C1, even if no objective reason permits the rejection of the date n° 4 (H-246/231 : 32,000) of which the too large sigma reduces the quality. Moreover, it is necessary to underline that the validity of the date n° 3 is maintained thanks to an other yielded by a sample from the layer C2 of the Schwallenbach site (GrN-21800 : 30,410) and which was found in a stratigraphic position quite comparable to that of the subunit C2 at Willendorf II. Such a similarity is not by chance and reinforces the hypothesis of climatic origin of the humiferous horizon C2 observed in the two sites and which can be attributed to the Stillfried B interstadial dated by HAESAERTS (1985, 1990 a, b) at the type locality (GrN-11188 : 28,900 +1500/-1300, top of Stillfried B soil).

The unique date n° 23 (GrN-17804 : 28,560) obtained from a charcoal cluster below the layer KS 6 perfectly harmonizes in the general sedimentation sequence. On the other hand, the 4 dates from the cultural layer KS 6

WILLENDORF II : radiocarbon dates

n°	sed. unit (U)	cult. layer (KS)	n° date	14C age (BP)	1 sigma	depth (m)	n° dating	material	weight (g)
30*	B 1	9	GrN - 21898	23,860	270	-	W - XXIV b	extern. bone (fract. 1)	> 50
31*	B 1	9	GrN - 22208	24,370	290	-	W - XXIV c	extern. bone (fract. 2)	> 50
32*	B 1	9	GrA - 5006	24,910	150	-	W - XXIV a	center of bone	32,00
33*	B 1	9	GrA - 5005	23,180	120	-	W - XXV	center of bone	26.90
11*	B 1	below 9	GrA - 893	23,200	140	2.5 - 2.6	W - VII a	charcoal	0.11
12a*	B 1	below 9	GrA - 493	23,400	190	2.5 - 2.6	W - VII b	charcoal	0.59
12b*	B 1	below 9	GrA - 494	23,670	120	2.5 - 2.6	W - VII b duplo	charcoal	0.59
13*	B 2	8	GrA - 917	22,180	190	2.95 - 3.00	W - XIX	collagen extr.	0.031
14*	B 2	8	GrA - 894	24,710	180	2.95 - 3.00	W - XVII	charcoal	0.84
15*	B 2	8	GrN - 17801	25,230	320	2.95 - 3.00	W - VIII a	charcoal	3.67
16*	B 2	8	GrN - 17802	25,660	350	2.95 - 3.00	W - VIII b	charcoal	3.35
17*	B 2	8	GrN - 21690	25,400	170	2.95 - 3.00	W - XX b	bones	> 50
18*	B 2	8	GrN - 20767	25,440	170	2.95 - 3.00	W - XX a	bones	> 50
1	B 2	8	GrN - 11191	25,800	800	-	W - I	charcoal	-
19a*	B 3	below 8	GrA - 491	23,830	200	2.80 - 3.40	W - IX	charcoal	0.28
19b*	B 3	below 8	GrA - 492	23,990	130	2.80 - 3.40	W - IX duplo	charcoal	0.28
20a*	B 4	6	GrN - 20768	26,500	480	3.65	W - XXI	charcoal	2.15
20b*	B 4	6	GrA - 1016	26,150	110	3.65	W - XXI duplo	charcoal	2.15
21*	B 4	6	GrN - 17803	27,600	480	3.65	W - X	charcoal	2.28
22*	B 4	6	GrA - 895	27,620	230	3.65	W - XXII	charcoal	0.9
23*	C 1	below 6	GrN - 17804	28,560	520	3.7	W - XI	charcoal	5,00
2	C 2	5	GrN - 11194	23,830	190	-	W - II	humus	-
24*	C 2	5	GrA - 218	27,270	290	3.90 - 4.10	W - XII	charcoal	0.71
3	C 2	5	GrN - 11193	30,500	900/-800	-	W - III	charcoal	-
4	C 2	5	H - 246/231	32,000	3000	-	-	charcoal	-
25*	C 4	4	GrA - 501	31,210	260	4.25 - 4.30	W - XIII	charcoal	0.74
5	C 4	4	H - 249/1276	31,700	1800	-	-	charcoal	-
6	C 4	4	GrN - 1273	32,060	250	-	-	charcoal	-
7	C 8	3	GrN - 11192	34,100	1200/-1000	-	W - IV	charcoal	-
26*	C 8	3	GrA - 896	37,930	750	4.80 - 4.90	W - XXIII	charcoal	0.32
27*	C 8	3	GrN - 17805	38,880	1530/-1280	4.80 - 4.90	W - XIV	charcoal	5.94
8	D 1 up.	below 3	GrN - 11190	39,500	1500/-1200	-	W - V	charcoal	-
28*	D 1 up.	-	GrN - 17806	41,600	4100/-2700	5.10 - 5.30	W - XV	charcoal	3.53
29*	D 1 mid.	-	GrN - 17807	> 36,000	-	5.40 - 5.60	W - XVI	charcoal	2.07
9	D 1 mid.	below 3	GrN - 11195	41,700	3700/-2500	-	W - VI	charcoal	-
10	D 3 ?	1 ?	GrN - 1287	30,530	250	-	-	charcoal	-

Table 1: Willendorf II; published and new Sc-004 (*) radiocarbon dates.

are illustrative of the interpretation problems that can occur when cross-dating in the loess. Two samples have been taken from the layer KS 6. The former (labeled W-X) has given the date n° 21 (GrN-17803 : 27,600) and the later has given 3. In fact, the second sample has been divided into two batches (labeled W-XXI and W-XXII) of which the first has given the conventional date n° 20a (GrN-20768 : 26,500) which was more than 1000 years younger than the date n° 21. In view of this discrepancy a second measure n° 22 (GrA-895 : 27,620) on batch W-XXII has confirmed the date n° 21 while a duplo in AMS n° 20 b (GrA-1016 : 26,150) on the lot W-XXI was nearer to the date n° 20 a. The consequence is two groups of two dates separated roughly by 1100 years of which 3 dates (1 conventional and 2 AMS) come from the same sample. We understand such apparent contradiction as an effect either of a contamination having influenced at the same time the conventional and the AMS measurements or of the solifluction bringing older elements into the layer. The stratigraphical and sedimentological data appears to confirm the hypothesis of the solifluction along the pronounced slope towards the Danube and, if we take into account the sedimentary rupture between the units C and B, the pair of dates n° 21 - 22 in B 4 appear to be too close to the date n° 23 coming from C 1. On this basis we conclude that the layer KS 6 must be dated around 26,500 to 26,150 BP.

The radiometric results on the cultural layer KS 8 (n° 1, GrN-11191 : 25,800; n° 14, GrA-894 : 24,710; n° 15, GrN-17801 : 25,230; n° 16, GrN-17802 : 25,660; n° 17, GrN-21690 : 25,400; n° 18, GrN-20,767 : 25,440) form a very coherent whole of 6 datings obtained at the same time on charcoal (n° 1, 14, 15, 16) and on bone (n° 17 and 18). We have excluded from this group the date n° 13 (GrA-917 : 22,180) which comes from a collagen extract badly purified for dating purpose. While the sample W-I collected by HAESAERTS (1990 a) gave an age of 25,800 (n° 1), the charcoal found in 1993 in the remains of a hearth have given ages between 24,710 (n° 14) and 25,660 (n° 16). Moreover the bones found next to this hearth have given two dates 25,400 (n° 17) and 25,440 (n° 18). The figure 5 (graph B 1) illustrates this concentration of dates around 25,500 and puts into evidence the slight updating that affects the date AMS n° 14, which comes undoubtedly from a contamination. In the present case, the dates on charcoal frame the dates on bones. This distribution can result in part from the

"old wood" effect but this hypothesis must be tempered by the extension of the sigma - mainly that of GrN-11191 (n° 1) - which are completely overlapping. Therefore we can estimate that the human occupation which corresponds to KS 8 was centered around 25,500 BP.

A small sample of charcoal was collected underneath this layer KS 8 within the B 3 loess. A double dating in AMS n° 19a (GrA-491) and n° 19b (GrA-492) has given an age between 23,830 and 23,990 the sigma not included. A slight contamination suffices for such an updating of the material within the unit B3 to have been put in evidence by the AMS. On the contrary, two lots of charcoal isolated from the upper loess (subunit B 1) have given three AMS datings - including a duplo - very concentrated (n° 11 : GrA-893, n° 12a : GrA-493 and n° 12b : GrA-494) between 23,200 and 23,670 with a very small sigma. The data are coherent between themselves but, regarding the previous AMS results, a slight contamination cannot be excluded even if the dates are found within the general chronologic sequence.

For the first time, a dating was attempted on the cultural layer KS 9, the one that gave the famous "Venus of Willendorf". The examination of the data from the excavations of BAYER and of FELGENHAUER (1956-1959) led to the conclusion that the position of KS 9 was just at the top of the upper loess cover and more than 1 m above KS 8. Therefore it could not be recorded in the 1993 section. Thus, a solution was to find, with the help of our Viennese colleagues in the collection of the Naturhistorisches Museum Wien, remains of bones uncovered by the excavators and still in a state to undergo a radiometric dating. In this manner we have acquired two pieces of bone (a bone fragment n° 72444 and a piece of mammoth scapula n° 72423, FELGENHAUER 1956-59: 48-49), the last one labeled "Willendorf II, KS 9, Venusgrube" by the excavator. We have chosen these objects because of their dimension and their density still high and apparently favorable for collagen conservation. However the treatment of these bones with a preservative and the reconstruction of the shoulder-blade with glue represented a serious inconveniency.

In agreement with the Groningen laboratory, our work consisted in removing the outer brownish layer of the bone pieces in

order to isolate the whitish central parts apparently not or less contaminated (figure 2). Datings were attempted not only on the whitish central part (n° 32) but also on the remaining brownish bone debris (n° 30, 31) of the bone piece n° 72444.

Clearly the bone age increases with the density and the conservation state of the material so that the date GrA-5006 appears as the most reliable whilst the younger ages of

the outer part of the same bone piece can be easily explained by the difficulty of completely removing the chemical preservative used at the Vienna Museum. This phenomenon could also be at the origin of the youngest date (GrA-5005) of the shoulder-blade piece (n° 72423) which was somewhat spongy, even in its inner part, and probably more contaminated with the preservative.

Willendorf II, KS 9:

n° 30	Bone 72444 outer part	GrN-21898:	23,860 ± 270	(fraction 1)
n° 31	Bone 72444 outer part	GrN-22208:	24,370 ± 290	(fraction 2)
n° 32	Bone 72444 inner part	GrA-5006:	24,910 ± 150	
n° 33	Bone 72423 inner part	GrA-5005	23,180 ± 120	

In any case, the dates available for the cultural layer KS 9 are a little older than those from the underlying horizon (n° 11 and 12 a, 12 b). Such a result points to a good quality of the collagen extracts. On the other hand, this relative downdating of the bones could be explained either by an eventual contamination of the underlying charcoal or by a supposed belated use of ancient bones uncovered at the loess surface by Gravettian people, after the elegant suggestion by O. SOFFER (1985). In the absence of charcoal, this last hypothesis is

hardly verifiable. Provisionally and with the present data, the age of the KS 9 layer can be estimated between 24,910 and 23,180 BP.

Chronological synthesis on the Willendorf site

The next table 2 summarizes the chronological limits of the successive cultural layers as suggested by the available radiocarbon data.

cultural layer/sedim. unit	industry	time limits (median dates)
KS 9	Gravettian	24,910 - 23,180
KS 8	Gravettian	25,800 - 25,230
KS 6	Gravettian	26,500 - 26,150
KS 5	Gravettian	± 30,500
KS 4	Aurignacian	32,060 - 31,210
KS 3	Aurignacian	38,880 - 37,930
unit D upper	-	41,700 - 39,500

Table 2 : Willendorf II (Lower Austria); chronological ¹⁴C limits attributed to the human occupations.

Finally the graph B 2 (figure 6) represents the chronological distribution of the reliable dates with regard to their stratigraphical origin (radiocarbon sampling) and gives our proposals for the local (right) and general (left) chronostratigraphical

interpretations after the comparison with other sites in Central Europe.

4. 2. Schwallenbach

The Schwallenbach site presents a special interest from its proximity with the Willendorf II site and also from many stratigraphic similarities between both sites observed by HAESAERTS (1990 a and b). This

parallelism was confirmed at the occasion of new investigations by the Sc-004 team and the aim of the datings (table 3) is evidently allowing a chronological control of the proposed correlations.

layer	n° date	¹⁴ C age	1 sigma	material	ch. weight
C 2	GrN - 21800	30,410	480 / - 450	charcoal	2,33
D b	GrN - 21801	39,920	1300 / -1100	charcoal	3,29

Table 3 : Schwallenbach (Lower Austria); new Sc-004 radiocarbon dates.

The first observation is the acceptable correspondance (taking the sigma into account) between the date 39,920 of the layer Db at Schwallenbach and the dates obtained from the unit D of Willendorf II (n° 8, GrN-11190 : 39,500; n° 9, GrN-11195 : 41,700; n° 28, GrN-17806 : 41,600 and even n° 29, GrN-17807 : >36,000).

The pedological character and the mollusc assemblages of the unit D both at Willendorf and Schwallenbach, and dated between 41,700 and 39,500, appear as the manifestation of a climatic amelioration for which the denomination of "Willendorf interstadial" is proposed.

A previous radiometric date from this site (GrN-16326 : 36,700 ± 1300) has been obtained by BRANDTNER on charcoal from the heterogeneous loams in the upper part of the layer D (HAESAERTS 1990 b). Taking into account its standard deviation of 1300 years and the differences with regard to the Willendorf results, the date 36,700 appears clearly updated by contamination.

The humiferous horizon topping the layer Dh at Schwallenbach corresponds to the unit C8 including the first Aurignacian cultural layer (KS 3) at Willendorf II where it was dated between 38,880 and 37,930. It seems also related to a climatic amelioration, traced

by pedological and mollusc assemblages, which is named here "Schwallenbach interstadial".

We also gathered charcoal in the humiferous layer C2 which was correlated with the subunit C2 (= KS 5) of Willendorf II (HAESAERTS 1990 a and b) for which we have retained an age of 30,500 + 900/-800 (GrN-11193). At Schwallenbach, we have obtained the date GrN-21800 : 30,410 +480 /-450 which entirely confirms the first one. It is necessary to insist on the importance of this concordance which supports the correlation between the two sites and emphasizes the dimension for the least regional of the climatic amelioration marked by the humiferous layer C2. The climatic significance is moreover reinforced by the fact that no artefact has been uncovered in this horizon sectionned 50 m in length. This amelioration is attributed to the Stillfried B interstadial. We are still waiting for 4 datings from the same horizon C2 and from three other sedimentary subunits.

4. 3. Grubgraben (Lower Austria)

To the present, 3 dates have been published about the main archaeological complex AL 2 - AL 4 (HAESAERTS 1990 c) but a set of some 5 complementary dates are also available for the upper layers (table 4).

layer	n° date	¹⁴ C age	1 sigma	material
AL 1	Lv-1825	16,800	280	bones
AL 2 a	Lv-1823	18,070	270	bones
AL 2 b	Lv-1821	17,350	190	bones
AL 2 b	Lv-1822	18,620	220	bones
AL 3	Lv-1810	18,030	270	bones
AL 4 - AL 3	Lv-1660	18,170 *	300	bones
AL 4	Lv-1680	18,400 *	330	bones
AL 4	AA-1746	18,960 *	290	bones

Table 4 : Grubgraben (Lower Austria); published (*) and complementary radiocarbon dates.

Therefore the first certified Epigravettian occupation of the site (AL 4) was estimated between 18,400 and 19,000 BP. Given the condensed succession of the 4 archaeological levels, the spread of the results

required a control made easier by the large stock of bones found in AL 4. Therefore a new dating was made on a mixture of 1 kg of reindeer and horse bones which has given the following result (table 5):

Layer	n° date	¹⁴ C age	1 sigma	material	bone weight
AL 4	GrN - 21893	18,820	160	outside bone	1 kg
AL 4	GrN - 21790	19,270	80	inside bone	1 kg

Table 5 : Grubgraben (Lower Austria); new Sc-004 radiocarbon dates.

This result confirms and makes the AL 4 layer a little older than 19,000 BP when the date GrN-21790 is taken into consideration. The group of the AL 4 - AL 3 humiferous horizons should correspond to a climatic amelioration while the AL 2 - AL 1 layers are included in the upperlying loess (HAESAERTS 1990 c).

4. 4. Other Central European sites

Firstly we will examine a selection of dates from Dolni Vestonice and then from other related sites. The next table 6 is established with data taken in the publications of KLIMA (1963, 1976, 1987, 1995), VOGEL and ZAGWIJN (1967), SVOBODA (1985a, 1985b, 1986, 1991, 1994a, 1994b, 1995), HAESAERTS (1990b) and VAN DER PLICHT (in press). From this table a number of accurate dates have been selected and other ones are discarded for various reasons. Thus, from Dolni Vestonice II, the dates GrN-2102 (n° 1), GrN-2093 (n° 2), GrN-2092 (n° 3) on humus and GrN-11003 (n° 5) on ash and very small charcoal pieces from a disturbed fireplace are doubtful. With the exception of the date ISGS-1744 (n°11), the dates from the Illinois laboratory are also unsatisfactory with regard to other dates from the same places (SVOBODA 1991, 1994 b). In the same perspective, the dates CU (n° 16, 18, 25, 29) appear clearly updated with regard to the GrN dates from the same horizon (SVOBODA 1991, 1994) and to their low amount of datable carbon (SILAR 1991). Notably CU-715 (n° 29) from the accumulation of mammoth bones at the foot of the western slope and not directly connected with the human occupations appears to be much too young with regard to GrN-14830 (n° 28).

From Dolni Vestonice I, some dates seem of low reliability because their eventual connection with the cultural layer or with the underlying paleosol appears unclear (n° 41: GrN-18188, n° 42: GrN-18187). We can also reject the two Ly datings on charcoal for evident reasons of updating as well as GrN-11004 (n° 35) on humus which comes from the same horizon as GrN-11189 (n° 38) on charcoal.

The datings from Pavlov could be regarded as accurate but GrN-1272 (n° 1) and GrN-4812 (n° 3) are suspected to derive from the same sample, reason for which we have selected the older date GrN-4812 as probably the most reliable. Moreover, GrN-19539 (n° 6) and GrA-192 (n°5) come from the same sample Pavlov-1953 and are the result of a double check giving a younger AMS date probably due to some contamination (VAN DER PLICHT in press). Consequently, the conventional date is held as the most accurate.

The date from the organic layer of Bulhary (Hv-10855) is given here as a result associated with a detailed palynological record of the Upper Palaeolithic in the next Dyje valley (RYBNICKOVA and RYBNICEK 1991). Unfortunately, if the median value fits well with the Pavlovian, the sigma is much too large probably due to the low amount of carbon in the sample.

From the Predmosti site, two dates were obtained from the same sample of bones. The older date from the extract (GrN-6801) seems more reliable than the date on the residu (VAN DER PLICHT, in press).

The selected results are transferred on the following graph B (figure 7) which allows a better comparative overview on the distribution of the dates in the sites. It clearly appears from the figure that the date GrN-

CENTRAL EUROPE: radiocarbon dates of selected sites

n°	Horizon	n° date	14 C age (BP)	1 sigma	material
DOLNI VESTONICE III					
30	Hearth, 1993	GrN-20392	24,560	660/-610	charcoal
DOLNI VESTONICE I					
31	Loess below the recent black soil, sample 3	GrN-6861	10,100	500	charcoal
32	Cultural layer, sample 1	GrN-6857	25,790	320	charcoal
33	Excavation Karel Absolon (1936)	GrN-1286	25,820	170	charcoal
34	Hearth 1, zone D, 1979, (sample P.H.)	GrN-10524	26,430	190	charcoal
35	Disturbed findhorizon below the cultural layer	GrN-11004	20,270	210	humus
36	Findhorizon below the cultural layer, sample 6	GrN-6859	27,790	370	charcoal
37	Browner horizon below the cultural layer, sample 8	GrN-6860	29,180	460	charcoal
38	Findhorizon, lower part of the site (stat. A), soil W 2/3	GrN-11189	31,700	1000	charcoal
39	Browner soil, W2/3	GrN-6858	32,850	660	charcoal
40	Upper part of the site, trench 10/90, cultural layer	GrN-18189	25,950	630/-580	charcoal
41	Lower part of the site, trench 1/90 (upper layer)	GrN-18188	27,250	590/-550	charcoal
42	Lower part of the site, trench 1/90 (lower layer)	GrN-18187	29,300	750/-690	charcoal
43	Middle part of the site, zone C	Ly-1303	22,250	570	charcoal
44	Middle part of the site, zone C	Ly-1999	19,640	540	charcoal
PAVLOV I					
1	Cultural layer, 1956	GrN-1272	26,620	230	charcoal
2	Cultural layer, 1956	GrN-1325	25,020	150	charcoal
3	Cultural layer, 1956	GrN-4812	26,730	250	charcoal
4	Cultural layer	GIN-104	26,000	350	charcoal
5	Cultural layer, 1953, (east)	GrA-192	25,530	110	charcoal
6	Cultural layer, 1953, (east)	GrN-19539	26,650	230	charcoal
7	Cultural layer, 1957, (west)	GrN-20391	26,170	450	charcoal
8	Cultural layer, excavation 1954,	KN-1286 ?	26,580	460	charcoal
9	Browner soil below the cultural layer 1972	KN-286 ?	30,010	460	charcoal
BULHARY					
B	Organic sediment (peat & clayed peat)	Hv-10855	25,675	2750/-2045	cl. peat
PREDMOSTI					
1	Cultural layer, burial 1971, charred bone (residu)	GrN-6852	26,320	240	ch. bone
2	Cultural layer, burial 1971, charred bone (extract)	GrN-6801	26,870	250	ch. bone

Table 6: Central European selected sites; published radiocarbon dates

15327 : 27,080 ± 170 (n° 23) reflects the beginning of the main Pavlovian occupation at Dolni Vestonice. Six datings from the Upper Etage of the new brickyard give similar results centered around 27,000 BP. The dating GrN-13962 : 27,660 ± 80 (n° 8) may be a trace of the first settlements. It is also apparent that the occupation should have lasted a relatively long time with repeated dwelling phases, as stressed by the Moravian Palaeolithicians (KLIMA 1993, 1995, SVOBODA 1990, 1991, 1994 a,b,c,d), and that the Pavlovian installed during an Interstadial (named here Dolni Vestonice Interstadial) and subsisted through the next stadial up to about 25,500 BP (Burial DV XVI) as proposed by SVOBODA (1991). In such context the triple burial (DV XIII - XV) is placed just in the middle of the occupation phase (n° 12, GrN-14831 : 26,640 ± 110) (KLIMA 1995). It seems to make the link with the settlement at Dolni Vestonice I and perhaps with the Pavlov site where the occupation could have continued up to about 25,000 BP.

The other Pavlovian site of Predmosti is also dated just around this period of 26,900 BP, considering the date GrN-6801 from a charred bone extract as the best reliable (VAN DER PLICHT in press). Thus, the Predmosti settlement should correspond to the major occupation at Dolni Vestonice and Pavlov I.

The brown humic soil (W 2/3) in the loess below the cultural layers is dated between 31,700 and 29,180 BP (n° 38 : GrN-11189; n° 37 : GrN-6860 at Dolni Vestonice I and n° 7 : GrN-10525 at Dolni Vestonice II, old brickyard). A date of 30,010 ± 460 (KN-286?: 28,060 BC; n° 9) was obtained from the brown soil below the cultural layer of Pavlov. It is also recorded at Stranska Skala with a date of 30,980 ± 360 (GrN-12605, n° 1). Such dating of the paleosol W 2/3 leads to make the correspondance with the Stillfried B Interstadial which is estimated between 31,000 and 29,500 BP. The correlation with the unit C2 (KS 5) of Willendorf II seems evident.

The datings from Bohunice are presented here because they give raw indications on the Bohunician technocomplex in the loess above the paleosol of Bohunice (VALOCH 1976, HAESAERTS 1990 b). The Bohunician is also dated at Stranska Skala with three ¹⁴C measurements between 41,300 and 38,200 (Stranska Skala n° 4, 5, 6) while three others between 32,600 and 30,980 (Stranska Skala n° 1, 2, 3) are available for the

Aurignacian cultural layer, the upper one (n° 1) being included in a humic soil attributed to the Stillfried B interstadial.

The examination of the ¹⁴C data from the sites of Bohunice and Stranska Skala emphasizes the lag between the Bohunician and the Aurignacian occupation phases in the country. It is difficult to estimate the real time-span of these phases because the dispersion of the dates and their sigma are high. It appears to cross the Willendorf Interstadial up to the Schwallenbach Interstadial between around 43,000 and 38,000 BP but new datings are needed to improve the precision of the results.

For Spadzista (South Poland), we give four dates of which one (n° 4 : 31,000 ± 2000) comes from the humic soil and three other should date the Gravettian cultural layer in a solifluate loess but with a probable higher reliability for GrN-11006 : 24,380 (n° 3). Clearly, Ly-2544 on bone is too young.

The charcoal samples taken at the base of the upper loess of Spadzista indicate a time span from about 24,400 to 23,000 for the Gravettian occupation. Charcoal from the humic soil below the cultural layer have given a date of 31,000 ± 2000 but the sigma is much too high in comparison with the other ones. Nevertheless, this data is in accordance with the attribution of the soil to the Stillfried B Interstadial.

4. 5. *Mitoc Malu Galben (Roumania)*

The Mitoc Malu Galben site certainly figures amongst the most dated in Central Europe. However, CHIRICA (1984, 1986) and HONEA (1984, 1986 a & b, 1991, 1994) encountered serious difficulties in the chronological attributions of the Aurignacian and Gravettian archaeological concentrations because of the extreme spread of the ¹⁴C dates obtained from the lower levels up to the summit of the loessic sequence. The authors often put forward some "geoturbation" phenomena which are irrefutable in these deposits on the slope towards the Prut. However, it has appeared that some uncertainties existed as well concerning the precise stratigraphic origin of the samples submitted for datings. For this reason it became necessary to establish the most coherent chronology possible of occupations and sedimentation-erosion processes based on a detailed study of the stratigraphy of the site.

MITOC MALU GALBEN : radiocarbon dates

n°	Sedim. cycle	n° dates	14 C age (BP)	1 sigma	n° M M G R (Chirica)	square (Chirica)	depth (m) (Chirica)	depth (m) (Haesaerts)	material	weight (g)
1	2a	GrN - 13765	20,150	210	8	J 7	3.10	1.95	bone	-
2	2b	GrN - 14031	20,300	700	60	J 6	3.65	2.55	charcoal	-
60*	3b	GrA - 5000	20,540	110	-	O 4	-	3.36	antler	29.65
56*	4a	GrA-1353	23,850	100	-	M 01	-	4.60	charcoal	0.57
3	4b	OxA - 1779	23,650	400	64	H 8	4.85 - 5.00	3.75 - 3.90	bone	-
4	4b	GX - 9422	24,620	810	17 A - C	B 7	5.00	4.15	charcoal	-
5	4b	GX - 8723	> 33,000	-	3	B 6	5.00 - 5.20	4.20 - 4.40	charcoal	-
40*	5a	GrN - 20438	23,390	280	-	N 01	-	4.90 - 5.20	charcoal	3.63
6	5a	GrN - 15448	> 23,000	-	69	J 6	5.75	4.65	charcoal	-
7	5a	GrN - 15805	23,490	280	68	J 3-4	6.15	4.75	bone	-
8	5a	GrN - 14034	23,830	330	70	J 5	5.75	4.70	charcoal	-
9	5a	OxA - 1780	24,650	450	67	J 8	5.40	4.20	bone	-
10	5a	GrN - 12635	27,150	750	32 - 35	G 1	6.35	5.60	charcoal	-
11	5b	GX - 8724	19,910	990	5	D 3	6.10	5.35	charcoal	-
12	5b	GX - 9424	> 21,000	-	22	G 7	5.60	4.55	bone	-
41*	5b	GrN - 20439	23,990	250	-	M 5-6-7	-	5.70 - 5.80	charcoal	3.82
14	5b	GX - 9425	24,820	850	23	G 7	5.60	4.55	charcoal	-
13	5b	GX - 8725	> 28,700	-	6	F 5	6.40	5.45	charcoal	-
15	6a	GX - 9423	17,300	2100 / - 1670	20 A - B	A 4	6.80	6.20	charcoal	-
16	6a	GX - 9429	19,900	1050 / - 930	16	C 6	6.60	5.90	bone	-
17	6a	GX - 8503	20,945	850	2	C 2	7.00	6.40	charcoal	-
18	6a	GX - 9420	22,050	1250	12 A - B	C 6	6.60	5.90	charcoal	-
54*	6b	GrA - 1020	24,070	180	-	M 5	-	6.7	charcoal	2.36
19	6b	GrN - 14036	25,140	210	74 A - D	G 4	7.00	6.10	charcoal	-
20	6b	GrN - 15450	25,610	220	75 A - B - C	G 4	7.00	6.10	charcoal	-
42*	6b	GrN - 20440	25,610	500 / - 470	-	M 3 - 4	-	6.50 - 6.70	charcoal	8.5
21	6b	GrN - 15449	26,100	800	72	J 5	6.80	5.75	charcoal	-
47	6b	GrN - 18811	26,180	290	102	G 8	6.50	5.40	charcoal	-
22	6b	GrN - 14035	26,750	600	73	G 5	6.80	5.85	charcoal	-
55*	6b	GrA - 1354	26,450	130	-	M 5	-	6.7	charcoal	0.8
23	7a	GrN - 15808	25,840	90	71	J 7	7.00	5.85	bone	-
24	7a	GX - 9418	26,700	1040	9.A	B 5	7.10	6.35	charcoal	-

Table 7: Mitoc Malu Galben; published and new Sc-004* radiocarbon dates

MITOC MALU GALBEN : radiocarbon dates

n°	Sedim. cycle	n° dates	14 C age (BP)	1 sigma	n° M M G R (Chirica)	square (Chirica)	depth (m) (Chirica)	depth (m) (Haesaerts)	material	weight (g)
25	7b	GrN - 13006	23,070	180	45	A 3	8.15	7.60	bone	-
26	7b	OxA - 2033	24,800	430	44	A 2	8.15	7.85	bone	-
27	7b	GrN - 14913	25,330	420	47	C 4	8.15	7.45	charcoal	-
48	7b mid.	GrN - 18815	26,500	460 / - 440	151 a	L 8	-	7.25	charcoal	-
49	7b mid.	GrN - 18880	26,020	650 / - 600	151 b	L 8	-	7.25	charcoal	-
50	7b mid.	GrN - 18881	26,380	600 / - 500	151 c	L 8	-	7.25	charcoal	-
51	7b mid.	GrN - 18879	26,300	450 / - 430	152 a	L 8	-	7.25	charcoal	-
52	7b mid.	GrN - 18882	25,080	500 / - 470	152 b	L 8	-	7.25	charcoal	-
53	7b mid.	GrN - 18883	26,110	1050 / - 930	152 c	L 8	-	7.25	charcoal	-
28	7b	OxA - 1778	27,500	600	43	A 2	8.15	7.85	bone	-
29	7b	GrN - 12636	28,910	480	41 - 42	D 4	7.85	7.05	charcoal	-
30	8b	GrN - 15453	27,100	1500	52 - 53	C 5	8.70	7.95	charcoal	-
31	8b	GrN - 14914	27,410	430	50	B 4	8.70	8.00	charcoal	-
32	8b	GrN - 12637	31,850	800	49	B 4	8.70	8.00	charcoal	-
33	9b	GrN - 13007	> 24,000	-	48	B 6	8.60	7.80	bone	-
34	9b	GrN - 15451	26,530	400	79	H 3	9.45	8.90	charcoal	-
35	9b	GrN - 14037	26,910	450	78	H 7	8.65 - 8.75	7.90 - 8.00	charcoal	-
36	9b	GrN - 15454	29,410	310	80	H 3	9.45	9.10	charcoal	-
57*	9b	GrA - 1355	25,380	120	-	K 6	12,00	9.3	charcoal	0.18
37	10b	GrN - 15456	25,930	450	83	A 7	10.10	9.35	charcoal	-
58*	10b	GrA - 1648	31,000	330	-	J02, G5, L5-6	10.70		charcoal	1.3
38	11 sup.	GrN - 15457	24,400	2200 / -1700	86 A	D 5	10.65	9.80	charcoal	-
39	11 sup.	OxA - 1646	31,100	900	86 B	D 5	10.65	9.80	charcoal	-
44*	11 sup.	GrN - 20443	30,240	470 / - 440	-	J 4	-	10.90	charcoal	7.00
46*	11 sup.	GrN - 20770	31,160	570 / - 530	-	L 6 - 5	-	11.00	charcoal	3.18
43*	11 inf.	GrN - 20442	30,920	390	-	J 3	-	11.90 - 12.10	charcoal	7.41
45*	12a	GrN - 20444	31,160	550 / - 510	-	J 1-3-5	-	12.10 - 12.20	charcoal	3.81
59*	12 b	GrA - 1357	32,730	220	-	J 01	-	12.26 - 12.38	charcoal	0.35

Table 7: Mitoc Malu Galben; published and new Sc-004* radiocarbon dates

In the following table 7 are shown the previous 46 dates available and the 14 (*) dates realized in the framework of the project Sc-004. These are presented by sedimentary cycle and by chronological ^{14}C order.

The stratigraphic distribution of the Sc-004 dates is given in the figure 8. It shows a coherent chronological succession without any significant inversion. However, the 3 dates from cycle 6 b present a problem as the AMS dates n° 54 (GrA-1020 : $24,070 \pm 180$) and n° 55 (GrA-1354 : $26,450 \pm 130$) are not in agreement with the conventional date n° 42 (GrN-20440 : $25,610 +500/-470$). We will see in the discussion how to resolve this.

In order to compare more easily the 59 available dates, we have placed them on the graph A 1 (figure 9) which regroups the results by sedimentary cycle after restitution in the general stratigraphy. This means of illustration puts into evidence the large dispersion of the results within the majority of sedimentary cycles. It therefore became necessary to control the reliability of the dates by a detailed examination of the origin of the samples and their quality. This work has been realized thanks to the collaboration of the excavator V. Chirica. This examination has put forward the necessity of a selection of undisputable dates on the basis of constant criteria. Therefore we have rejected the dates coming from samples too small and with a ^{14}C activity too weak for a conventional dating. Doubtful samples of which stratigraphical origin was imprecise or absent from the excavation booklets have been put aside.

This results in a second graph A 2 (figure 10) which shows the 38 dates of normal quality and for which no negative argument has been found concerning their origin. The selection of the dates has been made on the basis of commentaries supplied by different isotopic analysis laboratories and by V. CHIRICA (1984, 1986 a and b) and K. HONEA (1991, 1994) in their various papers as well as in the correspondence available in the Institute of Archaeology of Iasi.

In this way, the results of the Geochron (Gx) laboratory has been put aside (n° 4, 5, 11, 12, 13, 14, 15, 16, 17, 18, 24) as the samples were generally too small to the point that certain amongst them (n° 5 and 13) did not have any ^{14}C activity. K. HONEA himself rejected them in his work of 1994 (p. 127) moreso for reasons of contradiction with his

system than anything else. We would stress that the reproch about the low activity of ^{14}C concerns in particular the samples n° 5, 11, 12 and 13. The following (n° 15, 16, 17 and 18) are catalogued as updated by HONEA in his work documents.

A certain number of dates coming from Groningen (GrN) have been put aside for various reasons. It has therefore been realized that a doubt subsisted concerning the origin of several samples not mentioned in the excavation booklets. For this reason the dates n° 7, 19, 20, 21, 22, 23, 33 and 38 have been prudently discarded. Moreover sample n° 25 could have permutated with an other one (HONEA in lit. MOOK 11/2/1986). The date n° 33 is also rejected because of low collagen content (MOOK in lit. 11/2/1986). Finally 10 samples relatively poor in carbon (n° 6, 20, 27, 30, 31, 34, 36, 37, 38) have given results at the limit of reliability and could be considered as *terminus ante quem* but there is no objective reason to reject them on this basis only (MOOK in lit. 15/6/1988).

The reliability of nearly all the dates obtained from Oxford (OxA) is recognized even though some at the acceptable limit of collagen content (12-15 mg/g). In particular, the case of samples n° 26 and 28 is interesting as they come from the same herbivore jawbone (CHIRICA, pers. com.) but n° 26 contained less collagen (7 mg/g) than n° 28 (10 mg/g) (HOUSLEY in lit. 5/8/88). Finally and again, the analysis of the second graph A 2 shows a certain number of dates that move away from the evolution line of the general chronology (n° 10, 29, 32 and 37) but without any other argument this is not a reason to discard them.

The sample n° 57 collected by a student during the 1993 campaign was also discarded because of its doubtful origin.

At the end of the selection, the graph A 2 (figure 10) becomes a work document which gives a more coherent evolutive picture of the sedimentary accumulation and of the Aurignacian and Gravettian occupations. This document will help us in the chrono-stratigraphic interpretation of the site.

The chronology of the site is given in the graph B (figure 11) which can be divided into three parts. The first column situates the chronological position of the interstadials recognized in Central Europe by the paleosols and/or palynology. The second gives the

chronological position of the samples selected which have been extracted from the 10 sedimentary cycles at Mitoc Malu Galben and the third column illustrates the chronostratigraphic interpretation of the local sequence.

The analysis of this graph helps us to decide which data is still unacceptable. If nothing can be said about the dates from the sedimentary cycles 4 to 2 because of the paucity of data, clearly the isolated date n° 10 from cycle 5a is separated from the upper group of dates for unknown reasons and must be rejected. Perhaps the date n° 9 could be a little older too. In contrast, the date n° 54 is too young regarding the dates n° 42, 47 and especially n° 55 which was obtained from the same Gravettian charcoal accumulation. Most probably the cause was a contamination underscored by the AMS measurement. Inversely, the dates n° 29 (perhaps 28) and 32 are much too old with regard to the trend of the other dates in the same sedimentary cycles. Finally, we have discarded the dates n° 34, 35 and 37 which are clearly made too young in such a context of sedimentation. Clearly these samples appear updated by contamination. Thus, at the term of our remorseless selection, only 31 dates over 59 are held as reasonably reliable.

Mitoc Malu Galben, as a sawing workshop used by Aurignacian and Gravettian people, contains an incredible number of artefacts (tools and mainly chips) which are distributed in a number of layers more or less individualized or connected, so that an attempt to define the occupation time limits appears to be a little vain - as suggested in some way by HONEA (1994) - if we realize that the site was almost continuously occupied by Aurignacian and Gravettian populations.

Nevertheless, our strong selection of dates from Mitoc Malu Galben leads to put in evidence three main ensembles of workshoping phases. The first one of Aurignacian culture (cycles 12a - 9b) would have lasted from about 33,000 up to 29,500 BP. Around 27,500 BP (cycle 8b), a new important Aurignacian occupation have begun directly relayed by the Gravettian peopling in the cycle 7b or maybe 8b already. This long settlement phase could have lasted up to about 23,000 BP (cycle 4a) but we should distinguish a subdivision between a former period from around 26,500 up to 25,000 (cycles 7b - 6b) and a later one from 24,000 up to 23,000 BP (cycles

5b - 4a). Finally, the radiocarbon dates point to a hiatus between cycles 4a and 3b.

4.6. Cosautsi (Moldavian Republic)

At Cosautsi, an Upper Palaeolithic multilayered site on the west bank of the Dniepr in North-East Moldavia, a ± 18 m loess record provided a stratigraphic sequence encompassing the whole Upper Pleniglacial and the Late Glacial periods (figure 12). The interest of the site also lies in some 20 occupation horizons found in the loess sequence with numerous Upper Palaeolithic encampments remarkably documented with abundant stone and bone industries mostly associated to multiple hearths rich in charcoal.

Together with the 7 new Sc-004 datings, we have at our disposal a set of 22 radiocarbon dates on charcoal for some 12 occupation layers (table 8). We are waiting for 8 AMS datings on charcoal and also for 18 datings on bone debris collected by N. LOPEZ-BAYON (University of Liège) which should provide matter for a complete chronology of the site from 20,000 up to about 14,000 BP.

The table 8 and the next graph B (figure 13) allow an easy comparison between the new datings (* : all measured on *Picea* and *Pinus t. cembra* charcoal) and the previous ones (SVEZHENTSEV and POPOV 1993). The contrast between both sets of dates is striking moreover concerning their dispersion and their sigma. Inversions of dates are observed between some cultural layers. In such a dating system, it is difficult to decide which data are really accurate. The supply of the new datings is going to help us in that approach. Clearly the Sc-004 dates present somewhat higher values and more accurate ages than the other ones.

The distribution of the seven Sc-004 dates in the sequence is drawing up a coherent evolution between CL 9 (GrN-21795 : 19,410 \pm 100) and CL 2a (GrN-21792 : 17,230 \pm 140). The timing appears short between CL 3b and CL 4 (centered around 18,000) whilst a hiatus is apparent between CL 4 and CL 6b. All in all, the concentration of the dates are defining a relatively short period of around 2200 years corresponding to an accumulation of more than 3 m of loam but evidently with a varying deposition rate.

COSAOUTSI: radiocarbon dates

n°	Cult. layer	n° date	14 C age	1 sigma	material	weight (g)
1	1	GIN - 4146	17,200	300	charcoal	-
2	2 A	SOAN - 2460	16,940	1215	charcoal	
3*	2 A	GrN - 21792	17,230	140	charcoal	2.7
4	2 A+B	LE - 3304	16,860	770	charcoal	-
5	2 B	LE - 3305	15,520	800	charcoal	-
6	2 B	GIN - 4148	18,200	500	charcoal	-
7	2 B	SOAN - 2461	19,620	925	charcoal	-
8*	2 C	GrN - 21793	17,620	210	charcoal	2.2
9	3 B	LE - 3307	17,390	580	charcoal	-
10*	3 B	GrN - 21360	17,910	80	charcoal	8.4
11	3	GIN - 4149	16,160	250	charcoal	-
12	3	LE - 3301	17,400	340	charcoal	-
13	3	SOAN - 2462	17,840	550	charcoal	-
14*	3	GrN - 21359	18,030	150	charcoal	3.7
15	3 A + 4	GIN - 4150	17,100	250	charcoal	-
16	4	LE - 3308	17,640	830	charcoal	-
17*	4	GrN - 21794	17,950	100	charcoal	5.7
18	5	GIN - 4152	17,030	180	charcoal	-
19	6 A	Arizona	18,140	165	charcoal	-
20*	6 B	GrN - 21361	19,200	130	charcoal	2.1
21	6 C	Arizona	18,935	160	charcoal	-
22*	9	GrN - 21795	19,410	100	charcoal	6.0

Table 8: Cosautsi; published and new Sc-004 (*) radiocarbon dates.

It is worthwhile to stress the fact that the opposition between both sets of dates is not so important as it appears on the graph. A global satisfactory concordance can be found between the following datings n° 2: SOAN-2460 ($16,940 \pm 1215$) and n° 3: GrN-21792 ($17,230 \pm 140$), n° 13: SOAN-2462 ($17,840 \pm 550$) and n° 14: GrN-21359 ($18,030 \pm 150$), n° 16: LE-3308 ($17,640 \pm 830$) and n° 17: GrN-21794 ($17,950 \pm 100$). The trend is the same but an upward shift of varying importance is rather systematic with SOAN and LE regarding GrN datings.

The most salient feature from the data set is the recognition of two groups of dates, the former being associated with the cultural layers 2 to 4 and the later linked with the lower cultural layers 6 to 9. Moreover the hiatus materialized by the chalk-block horizon of the subcycle V 5 shows that the cultural layer 5 takes part and is the last one of the lower sequence. New AMS datings from CL 6a and CL 5 are in work and should confirm this interpretation.

4.7. The Kostienki area (Central Russia)

The famous Kostienki group of stations is also the most widely dated for the Upper Palaeolithic in Central Russia. However it is one of the best examples of the inconveniences linked to the multiplication of datings with various levels of accuracy, so that this key-site for the understanding of the Upper Pleistocene paradoxically needs some further datings of high security and precision.

The next table 9, established with the aid of N. Praslov and his team from various publications (ANIKOVICH 1993, ARSLANOV and SVEZHENTSEV 1993, BORISKOVSKI 1984, CHERDYNTSEV *et al.* 1965, 1968, GRICHUK *et al.* 1966, HEDGES *et al.* 1996, PRASLOV and ROGACHEV 1982, SVEZHENTSEV and POPOV 1993) and adapted by ourselves, presents the whole datings now available for the Kostienki and Borschchevo area. This table clearly shows that the great majority of the datings were made on bones, burnt bones and mammoth teeth whilst charcoal were secondarily used.

More than others, these sites present a very large distribution of the ^{14}C results. This is well illustrated in the next graph B (figure 14) showing the data from Kostienki 11, 21, 14 and 12. Clearly we can observe from this

graph a general scattering of the dates giving a rather imprecise picture of the local chronology as we can see in the cultural layer Ia of Kostienki 11.

The only exception would be the cultural layer II of Kostienki 14 which has given a set of three coherent dates both from bones (n° 69, LU-59b : $28,200 \pm 700$; n° 71, OxA-4115 : $28,580 \pm 420$) and from charcoal (n° 70, GrN-12598 : $28,380 \pm 420$). The date n° 39 from the cultural layer I (OxA-4114) which is archaeologically comparable to the cultural layer I of Kostienki 1 (ANIKOVICH 1993) should also be acceptable (HEDGES *et al.* 1996).

The Sc-004 team had the opportunity to realize a new stratigraphical study from the walls of a deep excavation pit in the station Kostienki 14 and uncovered with the Russian colleagues new charcoal pieces in the cultural layers III and IV (figure 15). A sample for ^{14}C dating was collected just at the base of the cultural layer III, in fact at the top of the whitish loam (ROGACHEV and SINITSYN 1982 : 146). It is interesting to stress the necessity of a careful selection of the pieces reserved for the dating because some remains of deciduous tree taxa (Malaceae, Prunoideae) were identified just like a charred grain of *Triticum* surely fallen from the top chernozern soil. The conventional dating on *Picea* charcoal has given:

Kostienki 14, cultural layer III

GrN-21802: $30,080 + 590/- 550$

This results has evidently nothing to do with the date n° 72, GIN-79 : $14,300 \pm 460$ (CHERDYNTSEV *et al.* 1965, 1968) realized on horse bones and this has a consequence on the dating of the human remains (n° Kostienki 2) brought to light just below the layer III in this site (GERASIMOVA 1982).

The new dating of the cultural layer III is complemented by an other one of the cultural layer IV taken in the white-brownish loam in between the volcanic ash and the lower humic horizon.

Kostienki 14, cultural layer IVa

GrN-22277: $33,280 + 650/- 600$

KOSTIENKI-BORSHCHEVO AREA: radiocarbon dates

n° n° date Sample, context, material 14 C age 1 sigma

Recent Chronological Group / Loessic Loam Bed

Kostienki 1

Cultural layer I

1	GIN - 1870	Burned bone	22 300	230
2	GIN - 2534	Burned bone	21 300	400
3	GIN - 2533	Pit dwelling (A), burned bone	22 300	200
4	GIN - 2530	Pit dwelling (Zh), burned bone	22 800	200
5	GIN - 2528	Pit dwelling (A), burned bone	23 000	500
6	GIN - 2527	Pit dwelling (A), burned bone	23 500	200
7	GIN - 2529	Pit dwelling (Z), burned bone	24 100	500
8	LE - 2800	Sq. (Th - 70), mammoth tooth	22 760	250
9	LE - 2801	Pit dwelling "with the wall"	21 800	200
10	LE - 2949	Cultural layer, mammoth tooth	19 860	200
11	LE - 2950	Storage pit (PR - 72), mammoth tooth	19 010	120
12	LE - 2951	Pit dwelling (F - 72, 73), mammoth tooth	23 770	200
13	LE - 2969	Cultural layer, mammoth tooth	22 700	250
14	LE - 3276	Sq. (L - 78), burned mammoth tooth	23 010	300
15	LE - 3279	Sq. (L - 77), mammoth tooth	21 680	700
16	LE - 3282	Storage pit, mammoth tooth	22 020	310
17	LE - 3287	Pit dwelling (T, H - 72, 75), mammoth tooth	23 260	680
18	LE - 3286	Pit dwelling (T, H - 72, 75), burned bone	23 490	420
19	LE - 3277	Cultural layer, burned bone	20 100	680
20	LE - 3280	Cultural layer, porous burned bone	18 230	620
21	LE - 3281	Sq. (O - 78), burned bone	19 620	460
22	LE - 3283	Pit, Sq. (K - 78), mammoth tusk	23 640	320
23	LE - 3290	Sq. (P - 76), burned bone	22 060	500
24	LE - 3292	Sq. (N - 76), pit, burned bone	19 540	580
25	GIN - 4851	Sq. (O - 73, 74)	20 800	300
26	AA - 4799	Cultural layer, burned bone	20 855	260
27	AA - 4800	Cultural layer, burned bone	20 315	200

Kostienki 2 (Zamiatnin site)

28	GIN - 93	Cultural layer, bone	11 000	200
29	LE - 1599	Cultural layer, bone (cave K-2)	16 190	150

Kostienki 11 (Anosovka site 2)

Cultural layer I a

30	LE - 1403	Cultural layer, bone	12 000	100
31	LE - 1637	Cultural layer, bone	14 610	120
32	LE - 1704 a	Cultural layer, bone	16 040	120
33	LE - 1704 b	Cultural layer, bone	17 310	200
34	GIN - 2532	Cultural layer, burned bone	19 900	350

Table 9: Kostienki; radiocarbon dates

Kostienki 11 (Anosovka site 2)**Cultural layer II**

35	GIN - 2531	Cultural layer, burned bone	21 800	200
36	TA - 34	Cultural layer, bone	15 200	300

Kostienki 11 (Anosovka site 2)**Cultural layer III sup.**

37	LE - 1638 a	Cultural layer, bone	16 040	120
38	LE - 1638 b	Cultural layer, bone	22 760	340

Kostienki 14 (Markina gora)**Cultural layer I**

39	OxA - 4114	Cultural layer, mammoth bone, H/70, trial trench	22 780	250
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Kostienki 19 (Valukinski site)

40	GIN - 107	Cultural layer, burned bone	11 800	500
41	LE - 1705 a	Cultural layer, bone	17 420	150
42	LE - 1705 b	Cultural layer, bone	18 900	300

Kostienki 21 (Gmelinskaia site)**Cultural layer II**

43	LE - 1437 a	Cultural layer, bone (Longin method)	19 100	150
44	LE - 1437 b	Cultural layer, bone (HCl-NaOH method)	20 250	100
45	LE - 1437 c	Cultural layer, bone (Combination method)	22 900	150
45 bis	LE - 1437 d	Cultural layer, bone (EDTA method)	19 050	130

Cultural layer III

46	LE - 1043	Cultural layer, charcoal	16 960	300
47	GrN - 7363	The same sample	22 270	150
48	GrN - 10513	Cultural layer, charcoal	21 260	340
49	TA - TL	Cultural layer, burned clay loam under the hearth	26 765	2000

Borschchevo 2

50	GIN - 88	Upper cultural layer, plant remains	12 300	100
51	IU - 742	Upper cultural layer, charcoal	13 210	270
52	Mo - 636	Upper cultural layer, humus	11 760	240

Table 9: Kostienki; radiocarbon dates

Middle Chronological Group / Upper Humus Bed**Kostienki 1****Cultural layer III**

53	GIN - 4850	Cultural layer, Sq. (D - 72), charcoal	24 500	1300
54	GIN - 4852	Cultural layer, Sq. (E - 72), charcoal	25 600	1000
55	GIN - 4885	Cultural layer, Sq. (D - 74), charcoal	26 200	1500
56	LE - 3541	Cultural layer, charcoal	25 730	1800
57	GIN - 4899	Cultural layer	25 900	2200
58	AA - 5590	Cultural layer, charcoal	38 080	5460/-3200

Kostienki 8 (Tel'manskaia site)

59	GrN - 10509	Cultural layer II, charcoal	27 700	750
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Kostienki 12 (Volkov site)

60	TA - 154	Cultural layer I, bone	20 900	390
61	GIN - 89	Cultural layer I, humus	23 060	300
62	LE - 1428 A	Cultural layer I a, bone (Longin method)	28 700	400
63	LE - 1428 B	Cultural layer I a, bone (HCl-NaOH method)	30 240	400
64	LE - 1428 C	Cultural layer I a, mammoth tooth (Combination m.)	31 150	150
65	LE - 1428 D	Cultural layer I a, mammoth tooth, (EDTA method ?)	31 900	200
66	GrN - 7758	Cultural layer I a, charcoal	32 700	700

Kostienki 14 (Markina gora)**Cultural layer II**

			25 090 ?	310
67	LE - 1400	Bone	19 300	200
68	LU - 59 a	Bone	26 400	660
69	LU - 59 b	Bone	28 200	700
70	GrN - 12598	Charcoal	28 380	220
71	OxA - 4115	Horse bone, P 43, 64; trench III	28 580	420

Cultural layer III

72	GIN - 79	Bone	14 300	460
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Kostienki 15 (Gorodtsov site)

73	LE - 1430	Cultural layer, bone	21 720	570
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Table 9: Kostienki; radiocarbon dates

n° n° date Sample, context, material 14 C age 1 sigma

Kostienki 16 (Uglianka)

74	LE - 1431	Cultural layer, bone	25 100	150
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Kostienki 17 (Spitsyn site)

Cultural layer I

75	GrN - 10511	charcoal	26 750	700
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Early Chronological Group / Lower Humus Bed

Kostienki 1

Cultural layer V

76	LE - 2030	Cultural layer, mammoth tooth	27 390	300
77	LE - 3542	Cultural layer, charcoal	30 170	570

Kostienki 14 (Markina gora)

Cultural layer IV

78	OxA - 4116	Cultural layer, horse bone, X/40, trench III	27 460	390
79	OxA - 4117	Cultural layer, horse bone, X/41, trench III	27 710	410

Kostienki 17 (Spitsyn site)

Cultural layer II

80	GrN - 10512	Charcoal	32 200	2000 / -1600
81	GrN - 12596	Charcoal	36 400	1700 / -1400
82	LE - 1436	Bone	32 780	300

Table 9: Kostienki; radiocarbon dates

The result is in a very good accordance with the preceding one and gives the opportunity to precise the chronological position of the marker ash layer between about 33,300 and 30,000 BP. This result also confirms the feeling of HEDGES *et al.* 1996 who suspected the previous datings (n° 78, OxA-4116 : $27,460 \pm 390$ and n° 79, OxA-4117 : $27,710 \pm 410$) of being distorted.

The next results of the important stations Kostienki 12 and 21 are given here to illustrate the difficulty of picking out the accurate data and interpreting the set of dates from a site. Thus, from the cultural layer Ia of Kostienki 12 we have 5 dates at our disposal of which the 4 dates labeled LE-1428 a, b, c and d are supposed to come from the same sample or batch of bones (ARSLANOV and SVESHENTSEV 1993) despite another labeling (charcoal bone / mammoth tooth) in SVESHENTSEV and POPOV (1993). It would appear in the first paper that the date n° 64 (LE-1428 c : $31,150 \pm 150$) should represent the most accurate result on bone material treated with a new effective method for collagen extraction and purification. But a date LE-1428 d ($31,900 \pm 200$, n° 65) probably obtained from an EDTA extraction mode also exists in the second paper. Finally, a fifth date was obtained on charcoal with the result n° 66 (GrN-7758 : $32,700$) which can provisionally be considered as the safest. Together with the new GrN-22277, this GrN-7758 date suggests a correlation between Kostienki 12 CL I and Kostienki 14 CL IV.

Kostienki 21 also produced some puzzling results. Concerning the layer II (PRASLOV and IVANOVA 1982), the dating n° 45 (LE-1437 c : $22,900 \pm 150$) realized with the new Russian method of collagen extraction is presently held as an example of the best one could obtain from a bone (ARSLANOV and SVEZHENTSEV 1993) but this date, attributed to layer III by the last authors, appears older than the accurate GrN dates on charcoal (n° 47, 48) from the lower layer III. Unfortunately, any trace of charcoal could not be found in the new section made at this place during the 1994 campaign.

At present, the Kostienki 1 station calls for a special attention on the one hand because of its archaeological wealth and on the other hand because it provided us with several additional charcoal samples to be dated (figure 15).

As indicated in the table 9, the dispersion of the dates, especially from cultural layer I, is striking. In order to visualize better and discuss easier such results we present the data on the following graph of our type B (figure 16) which gives the chronological distribution of the dates on burnt bones, teeth and charcoal.

Clearly the distribution of the dates extends from around 24,000 up to about 19,000 BP as well as from teeth as from bones. However we may stress the higher concentration of dates on teeth between 23,770 (n° 12) and 21,680 (n° 15). The lower limit around 24,000 BP could be eventually accepted as the starting moment of the settlement I but the eventuality of a possible deferred use of the bones cannot be rejected. Really such a quasi linear distribution does not make a clear interpretation of the data easier. The probability of a continuous occupation of the station 1 during more than 5000 years seems "a priori" low regarding to the stratigraphical data. In the present state of the question, we are unable to achieve a good interpretation and we hope that new datings on charcoal will supply decisive arguments.

Up to now, some 6 dates, all on charcoal, can be used as a basis for discussion about the cultural layer III. They range from $25,900 \pm 2200$ (GIN-4899) up to $24,500 \pm 1300$ (GIN-4850). The last one seems a little too young regarding the following ones centered around 25,750. We have obtained a new result from charcoal collected in the same layer :

Kostienki 1, cultural layer III

GrN-22276: $25,820 \pm 400$

Such a result is in a excellent agreement with the dates LE-3541 : $25,730$ (n° 56) and GIN-4899 : $25,900$ (n° 57) but the low sigma of the new date is due to the good quality of the material.

4. 8. Kurtak (Central Siberia)

The upper part of the Kurtak loess deposits have given 7 dating results on charcoal and bones (table 10) (DROZDOV and TCHEKA, pers. com., DROZDOV *et al.* 1990, SVEZHENTSEV *et al.* 1992, RUTTER and CHLACHULA 1995). These datings were

KURTAK : radiocarbon dates

n°	stratigr. unit	n° date	14 C age (BP)	1 sigma	material	weight (g)
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KAMINNI LOG

1	K 1 c	SOAN-3276	27,460	230	charcoal	-
2*	K 1 c	GrN-21895	27,920	260	charcoal	7.80
3*	K 2 b	GrN-21896	29,580	400 / - 460	charcoal	2.57
4	K 2 b	SOAN-3275	31,410	465	charcoal	-
5*	K 4 b	GrN-21358	33,740	500 / - 480	charcoal	4.10

CHANI (P 31 + Chani)

6	K 1 c	SOAN-3272	26,925	265	wood	-
7*	K 1 c	GrN-20872	27,070	170	wood	63.10
8*	K 1 c	GrN-20867	28,040	170	wood	143.90
9	K 2 b	SOAN-3273	29,010	325	wood	-
10*	K 2 b	GrN-20868	30,370	190	wood	175.20
11*	K 3 b	GrN-20869	31,880	350	wood	32.60
12	K 3 b	SOAN-3154	30,385	275	wood	-
13	K 3 b	AECV-1938 c	30,400	700	charcoal	-
14*	K 3 b	GrN-20871	32,870	275	wood	83.20
15	K 4 b	SOAN-3274	32,450	360	wood	-
16*	K 4 b	GrN-21357	33,390	560	charcoal	6.24
17*	K 4 b	GrN-20870	34,260	310	wood	56.40

Table 10: Kurtak; previous (partly unpublished, by permission of N. Drozdov, Krasnoyarsk) and new Sc-004 (*) radiocarbon dates.

focused on a succession of humiferous-organic layers which characterizes the so-called "Kurtak Pedocomplex" attributed to the Interpleniglacial period (figure 17). In the course of the stratigraphic study, large remains of wood and charcoal were uncovered. This represented an unexpected opportunity to test cross-datings with samples in the Novosibirsk ^{14}C laboratory.

As the same fundamental sequence was observed both in slope (Berechekhovo P 31 + Chani) and in plateau (Kaminni Log) situations, samples reserved for palaeobotanical and radiometrical analyses were systematically taken from the main organic layers observable in the 3 section walls.

The table 10 gives the 10 new Sc-004* results regarding the previous ones. It clearly appears that the Sc-004/GrN dates are forming a coherent succession as well as from charcoal as from wood but they are systematically a little older than the other SOAN ones, exception made for the stratigraphical unit K 2b at Kaminni Log.

When the whole data are reported on a graph B (figure 18), a same trend is outlined by both sets of data but with an updating of the SOAN samples. A good example of this concerns three datings from the same layer (K 3 b) submitted at the same time in Novosibirsk (n° 12, SOAN-3154 : 30,385), in Alberta (n° 13, AECV-1938c : 30,400) and in Groningen (n° 14 : GrN-20871 : 32,870). Such a shift is attributed to the difference in the laboratory treatments since the origin of the material is the same.

The spatial distribution in depth and time of the dates (figure 18) helps us in establishing correlations between the sections from Kaminni Log, Berechekhovo P31 and

Chani. With the GrN results we are able to situate the ^{14}C timing of the successive organic deposits around the following values.

K 1 c :	28,040- 27,010
K 2 b :	30,370- 29,580
K 3 b :	32,870- 31,880
K 4 b :	34,260- 33,390

Such a corpus of dates represents an effective tool to achieve accurate correlations which allows the setting up of the chronological framework (figures 17 and 18) of a palaeoenvironmental reconstruction with the aid of pollen and macroremains analysis.

It is important to stress the fact that such successive episodes correspond to organic and wood concentrations in which a palynological record (DAMBLON, in preparation) has shown parallel raisings in amounts of spruce and pine pollen, while steppic plants are dominant in the non organic strata. Such a close correspondence points to a positive climatic significance of the episodes recorded in the Interpleniglacial deposits of Kurtak, episodes named here Chani I, Chani II, Chani III and Chani IV from top to bottom (figure 17).

4. 9. Afontova Gora II (Central Siberia, Russia)

Afontova Gora is an other famous Late Glacial site which has been the object of a stratigraphical study by the Sc-004 team (figure 19). Four cultural layers and the lower humic layer have given the following 8 radiocarbon dates (table 11).

cultural layer	n° date	^{14}C age	1 s	material
2	GIN - 7542	13,310	140	bones
3 a	GIN - 7539	13,350	60	bones
3 a	SOAN - 3077	14,330	95	bones
4	GIN - 7540	13,650	70	bones
4	SOAN - 3075	14,070	110	bones
4	GIN - 7541	13,930	80	bones
5	SOAN - 3251	15,130	795	bones
lower humic layer	GIN-117*	20,900	300	charcoal

Table 11: Afontova Gora (Central Siberia); published (*) and unpublished radiocarbon dates (by permission of N. Drozdov, Krasnoyarsk).

The results strongly suggest a succession of occupation phases in a relatively short time from about 21,000 (CHERDYNTSEV *et al.* 1968) to the beginning of the Late Glacial but the wide overlapping of the dates and sigma does not give a clear overview on the chronology of the site. Moreover, it remains difficult to situate these settlements in a wider

chronostratigraphical framework. It is the reason why additional samples of charcoal were collected as well as in certain geological layers as in the main archaeological layers. The new results are given in the next table 12 while figure 20 presents the distribution of the Late Glacial dates.

layer	n° date	¹⁴ C age	1 s	material	weight (g)
cult. layer 3 b	GrN-22274	13,990	110	charcoal	3.48
geol. layer 6 a	GrN-22275	13,390	260	charcoal	4.12

Table 12 : Afontova Gora (Central Siberia); new Sc-004 radiocarbon dates.

With regard to the geological record, only the GrN-22275 (13,390 ± 260 BP) appears reliable because the paleosol 6 appears clearly *in situ*. On the contrary, the sedimentary unit 5, with the cultural layers 2, 3a and 3b, is solifluated and such a movement can explain a probable downdating of the cultural layer 3a as it was suggested by SOAN-3077.

DISCUSSION

In the present state of the work, general conclusions on the chronology of the Eurasian Plain would be premature. Nonetheless the amount of new data accumulated is considerable and allows open original perspectives on the chronostratigraphy of the area, on the palaeoenvironment of Upper Palaeolithic populations and on the climatic evolution having affected the largest continent of the world. In particular, chronological data obtained from material dated in loess deposits permits us to advance strong correlations between continental, oceanic and polar ice records.

The next discussions and conclusions concern the principal field-works treated in the research and present a few problems of which some remain open.

The precise stratigraphic origin of the sample was the first aim to achieve and it can be ascertained for almost all samples collected and dated, apart from rare exceptions coming from the acceptance of samples not directly collected by the Sc-004 team (Mitoc, n° 57).

With the help of minute stratigraphical recordings the direct relevance of the datings can be guaranteed.

A critical examination of the results is convincing about the reliability of charcoal as one of the safest material for radiocarbon dating. Of course all results are not 100% satisfactory due to uncontrollable effects of contamination but the careful trial of the fossil material and selection of the appropriate pieces have given a firm basis to obtain the best results possible. This has been tested with multiple datings on the same level, for example on the KS 8 of Willendorf II or by comparisons with previous datings on the same level (Mitoc Malu Galben sed. cycles 5a and 11). Some sample of unburnt wood, like these collected at Kurtak-Chani, have also given excellent datings.

Finally we should not complain about unburnt bones - once again on the condition we are sure of their precise stratigraphic origin and of the absence of reworking - which have given results of good precision and security at Willendorf II, Grubgraben and Mitoc.

We have evoked the problem of the possible use by Palaeolithics of old pieces of bones eventually conserved in the loess and brought to light by run-off, deflation and other erosion process (SOFFER 1985). This could be responsible for some downdatings but we have practically little means to test it when different types of material do not coexist in the same horizon. Any case, we did not have the opportunity to observe such a phenomenon, even in the cultural layer KS 8 of Willendorf II from which both bones and charcoal have produced close related results, and we have no

positive argument - the sedimentation mode being the same - to believe that the availability in wood changed and that Gravettians had adopted a different behaviour between the KS 8 and KS 9 epochs.

A general conclusion cannot be drawn about the impact of the charcoal dispersion in the sedimentary units on the quality of the datings. There is no rule and results have to be examined case by case taking into account the eventual sediment reworking and bioturbation. Collecting a sample in a fireplace is not really a guarantee of high accuracy as demonstrated in Mitoc (n° 44). In the present framework we got top quality results from dispersed charcoal samples - but precisely situated in the stratigraphy - as well as from concentrated ones in hearths (Willendorf, Mitoc) or in natural clusters (Schwallenbach).

The sampling method, founded on collecting charcoal from section walls and bankets, experienced and mostly used in the present project proved to be very safe and precise with regard to the stratigraphy.

The handling and treatment of charcoal in the laboratory constitute important step in the achievement of good material for radiometric dating. At first the dispersion of the sediment in water, successive chemical treatments (HF, HCl) - when adapted to the brittleness of the charcoal - and drying in the oven did not affect (or very little) the integrity of charcoal intended for identification and radiocarbon dating. Such a resistance of the charcoal can be explained by the long taphonomic process as burning, embedding, watertable and frost action, dessication, etc..., which resulted in pieces of various shapes conserved in the loess and paleosols. It is why the most resistant remains are supposed to have been gathered.

An other essential step is formed by the sorting operations of charcoal pieces and the elimination of all possible types of contaminants like rootlets, insect debris and other intrusive objects. This time-consuming work is worthwhile when we need charcoal as pure as possible for dating but it is rarely done by the datings consumer. Nevertheless, as careful the trial is, the complete elimination of all contaminants seems to be impossible to achieve. In the examination of the charcoal pieces under the microscope very thin rootlet filaments can appear in the light of the cells. It is clear that such contaminants cannot be totally eradicated. In this way, the task of the

anthracologist consists in selecting the best pieces the less polluted as possible. Despite these precautions we obtained some updating results as in the Willendorf (n° 24) and Mitoc (n° 54) sites. Only the reliability of the result may confirm the quality of the material and of the trial.

During the work we were convinced more and more about the necessity of charcoal identification before the submission to dating. In this perspective, each charcoal piece was analysed even for conventional datings. This is time-consuming too but it is the only way to pick up dubious taxa and discard them. For example intrusive taxa were suspected in Kostienki 14. This is the reason why charcoal from conifers growing in continental and cold climate, essentially *Picea* and *Pinus t. cembra/sibirica*, were selected for datings.

In the present state of the work, the AMS results are somewhat younger than conventional ones. This is exemplified in the Willendorf sequence where repeated datings have given younger AMS (sed. units C 8 - KS 3 : n° 26 and 27; B 4 - KS 6 : n° 20 a and 20 b; B 2 - KS 8 : n° 15 and 16), exactly as in the Pavlov 1953 site (VAN DER PLICHT in press). As clearly shown in the Gravettian accumulation of burnt material in the square M5 (sed. cycle 6b) of Mitoc Malu Galben, a pair of AMS datings have produced two very different results (n° 54 and 55) of which the later appears in better concordance with two conventional dates at least. The only explanation for such a distortion could be the extreme sensitivity of the AMS to the least contamination especially for low ¹⁴C content material.

Bioturbation could also be an other source of contamination inducing datings as perhaps in Willendorf II unit C2 (KS 5) or in Mitoc sed. cycle 10b. However, if an updating provoked by the intrusion of Holocene material would have been much larger than observed here, an accidental supply of charcoal from younger Pleistocene horizons is possible. Such bioturbations could have happened in particular at Willendorf where rootcastings and krotovines are present. Still however the intrusive phenomenon has not to be overestimated since the great majority of the results are really precise and accurate.

As it was expected, results obtained from the Groningen laboratory (GrN, GrA) are really satisfactory even with small samples at the C weight limit (+/- 50% C / 2g) for con-

ventional dating. Moreover some discrepancies between conventional and AMS results seem linked more to geological and biological factors than to laboratory handling and measurement. This was tested for example in the layer KS 8 of Willendorf II.

On the contrary, some doubts may appear about some American (Gx) and Russian (GIN, SOAN, LE) datings of which the reliability remains difficult to evaluate. On the one hand the quality of the results was certainly influenced by the poor quality of samples as mentioned in the mail between J. Honea and the Geochron laboratory. On the other hand the minimum weight needed for the Russian datings is supposed to be much higher than 2 g, a condition which implies gathering more charcoal and could raise the risk of contamination. In this light, it is acceptable that the GrN datings on charcoal from Cosautsi, from Kostienki and from Kurtak give results a little or much older than the GIN, LE and SOAN dates. In the absence of systematic cross-datings and interdatations on the same material, we cannot estimate the real role taken by sampling, laboratory handling, chemical treatment and ^{14}C measurements in the distortion of the results. However, an interdatation essay on a wood sample from Kurtak (K 3 b) points to a difference in the laboratory treatments.

6. CONCLUSIONS

The reliability of the dates obtained within the framework of the Sc-004 project is guaranteed by the system of collecting samples in direct relation with stratigraphy, by the careful treatment, sorting and identification of charcoal in the laboratory, and by the service of a same isotopic laboratory (Groningen) with a long experience of dating in Central Europe.

Nevertheless, some problems remain open notably concerning the factors inducing up- or downdatings. It seems that we have reached the limits of cleaning and purification of the charcoal. The contamination factor appears as the main obstacle to achieve better AMS datings and only chemical treatments for removing any trace of soft tissues could improve the accuracy of the results. The datings on bones have given satisfactory results but some doubt subsist about the possible use of old bones by the Palaeolithics.

This paper presents 66 new radiocarbon dates from 9 Upper Palaeolithic key-sites or groups of sites distributed from the Danube to the Yenisei Basins. Together with the available published data and 13 other new SC-004 datings from other sites they contribute in establishing a firm data base on which the chronology of loess depositions, of climatic variations and of human occupations from Western Europe to Central Asia should be worked out (figure 21). About 30 new datings are in work at the Groningen laboratory and will allow to improve the accuracy of the chronology of the climatic episodes.

The comparison of safe radiometric results with data from stratigraphy, palaeopedology and palaeobotany leads to a better understanding of the evolution of the environment and the human behaviour during the transitional period between the Neanderthal and modern man. In particular, the new radiometric results has revealed interesting points about the limits of most Interstadials which characterize the Interpleniglacial and Upper Pleniglacial periods.

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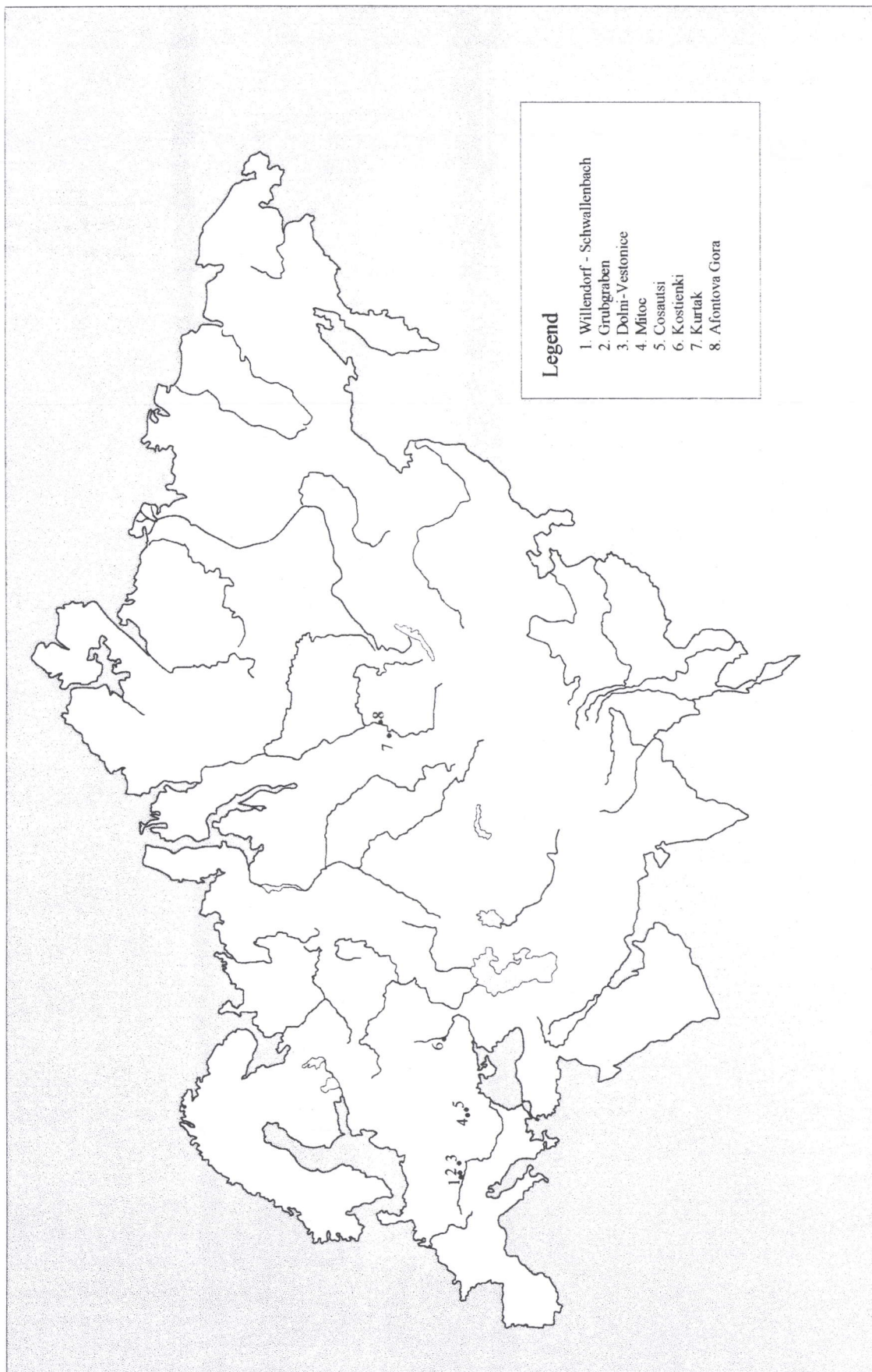
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- Legend**
- 1. Willendorf - Schwallenbach
 - 2. Grubgraben
 - 3. Dolni-Vestonice
 - 4. Mitoc
 - 5. Cosautsi
 - 6. Kostienki
 - 7. Kurtak
 - 8. Afontova Gora

Figure 1 : Location map of the investigated sites in Eurasia.

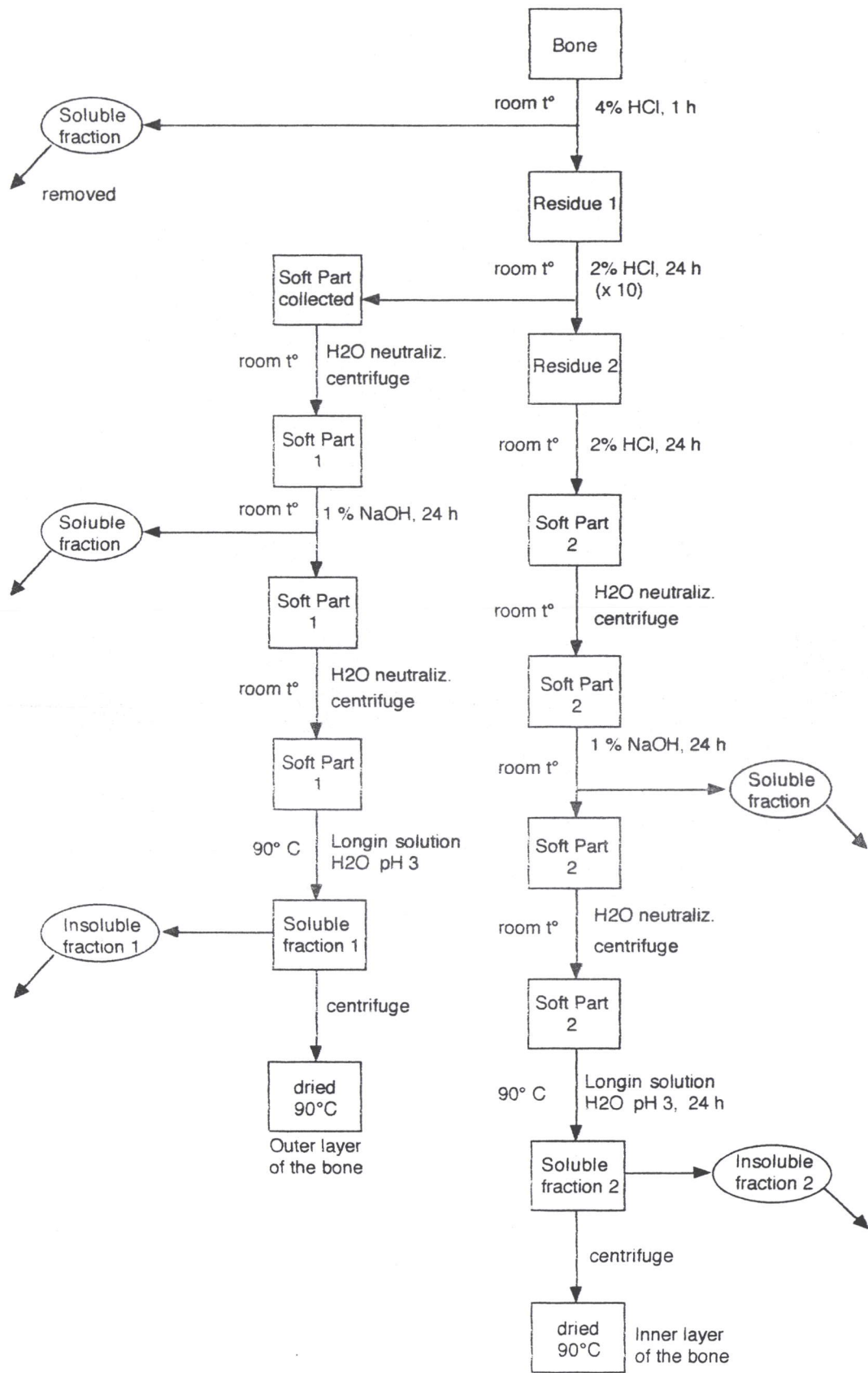


Figure 2 : Procedure of collagen extraction from bones in the Groningen laboratory.

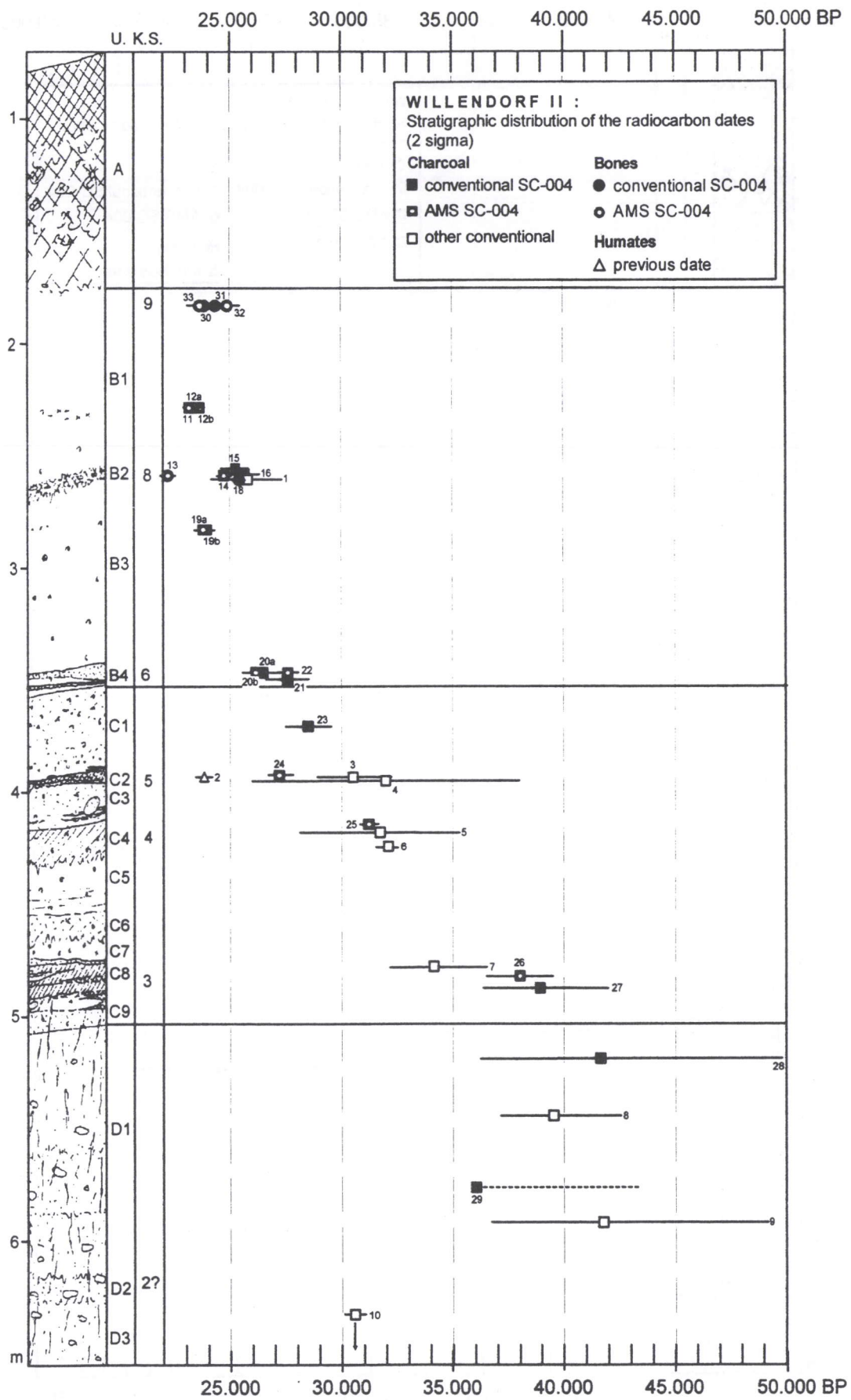


Figure 3 : Willendorf II; graph A 1, stratigraphic distribution of the whole dates.

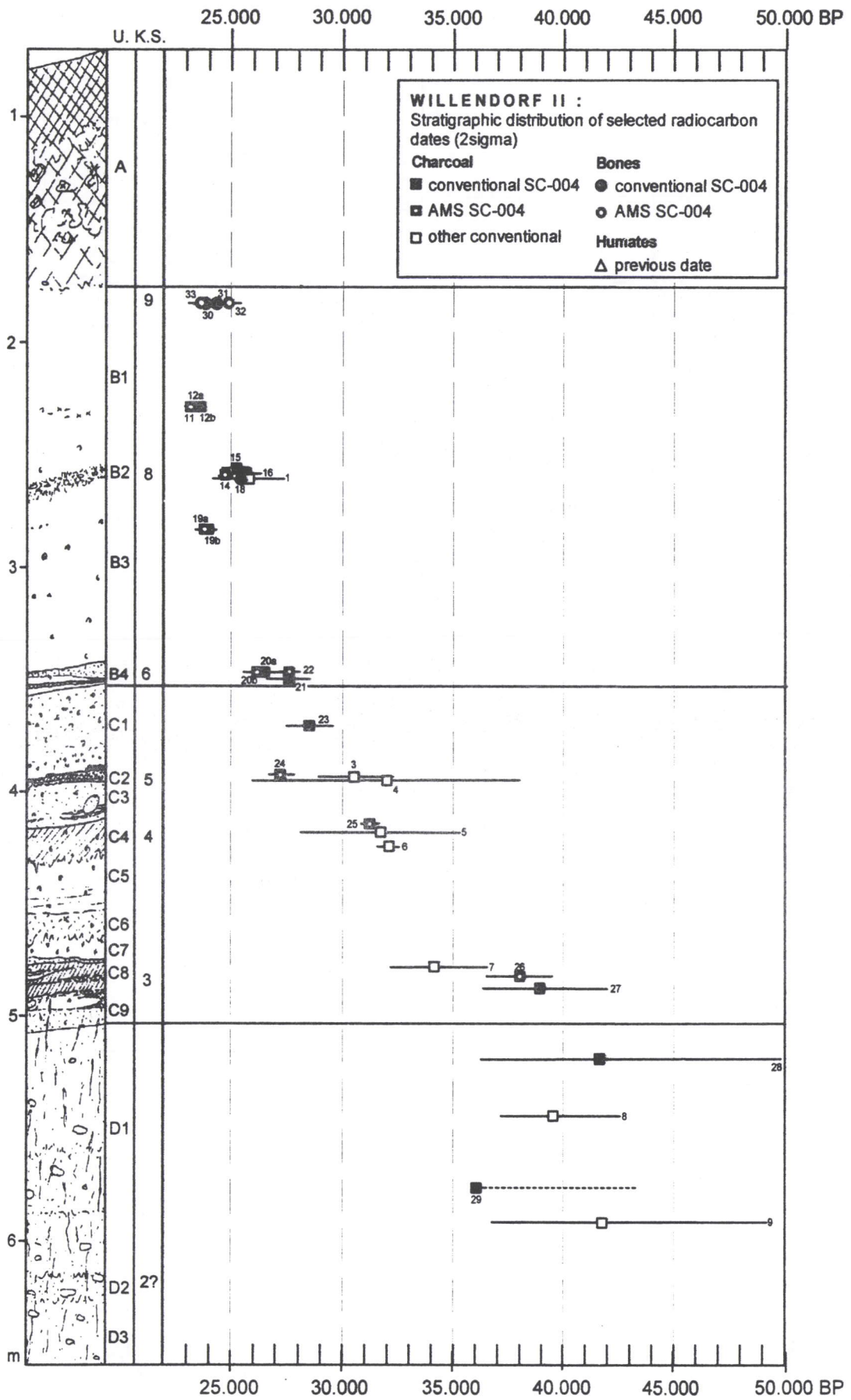


Figure 4 : Willendorf II; graph A 2, stratigraphic distribution of the selected dates.

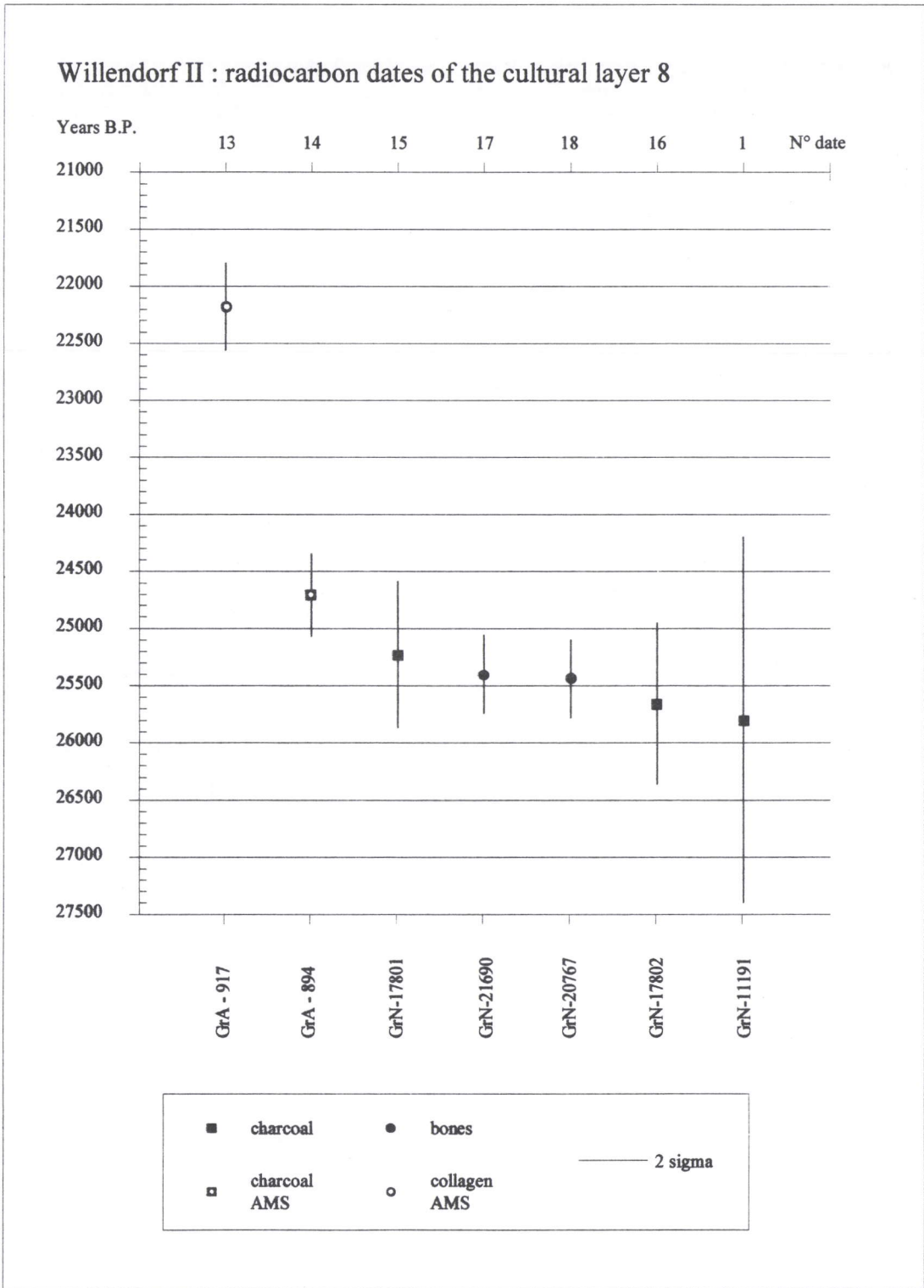


Figure 5 : Willendorf II; graph B 1, chronological distribution of the dates from the cultural layer 8.

Willendorf II : chronostratigraphy and chronology

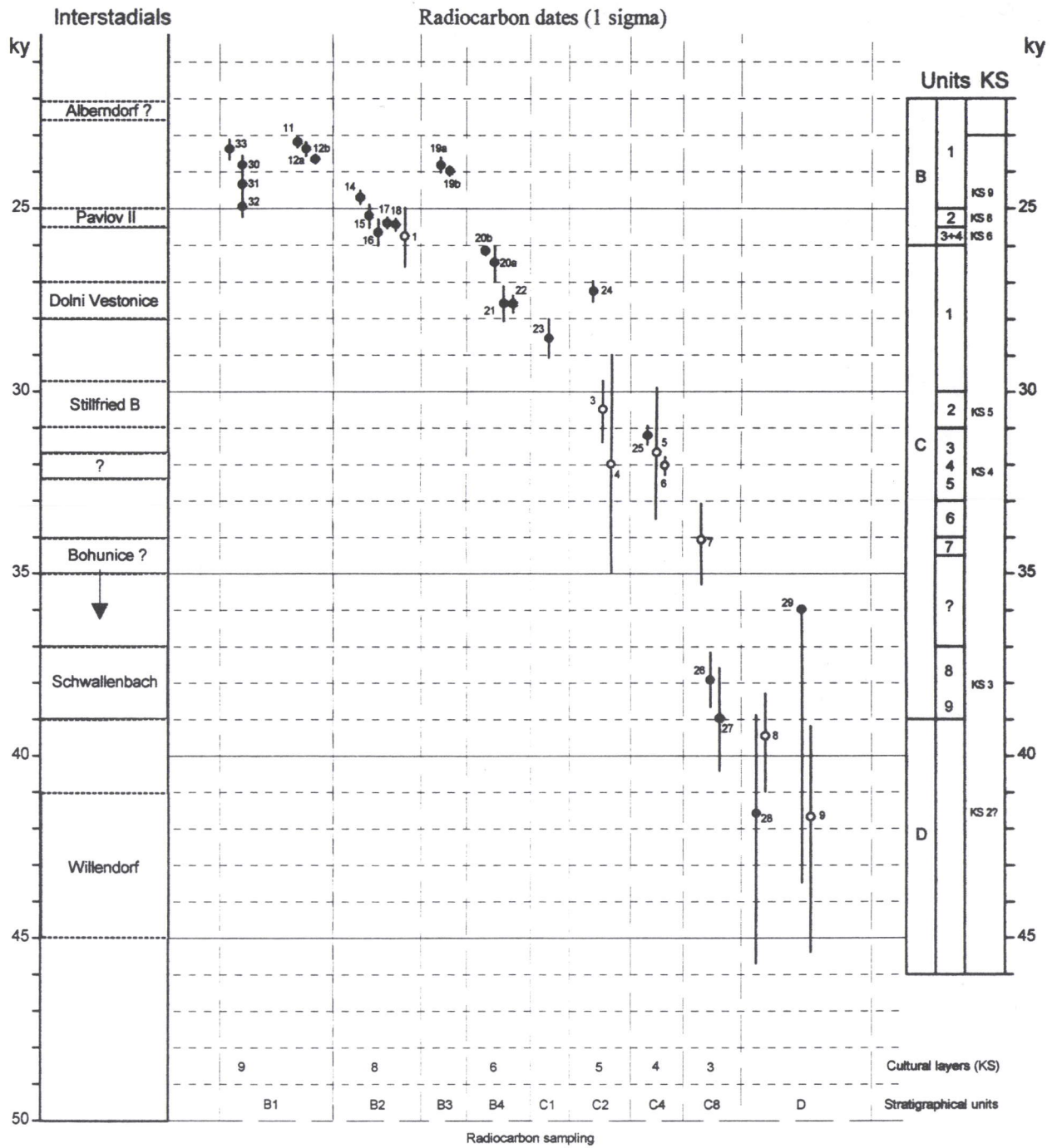


Figure 6 : Willendorf II; graph B 2, chronostratigraphy and chronology of the site. The central column gives the chronological distribution of the ^{14}C dates by stratigraphical unit and by cultural layer. Symbols: ● Sc-004/GrN & GrA dates; ○ other previous dates. Right side: local chronostratigraphy; left side: chronostratigraphy for Central Europe. Both left and right sides are interpretative.

CENTRAL EUROPE: Chronostratigraphy and chronology

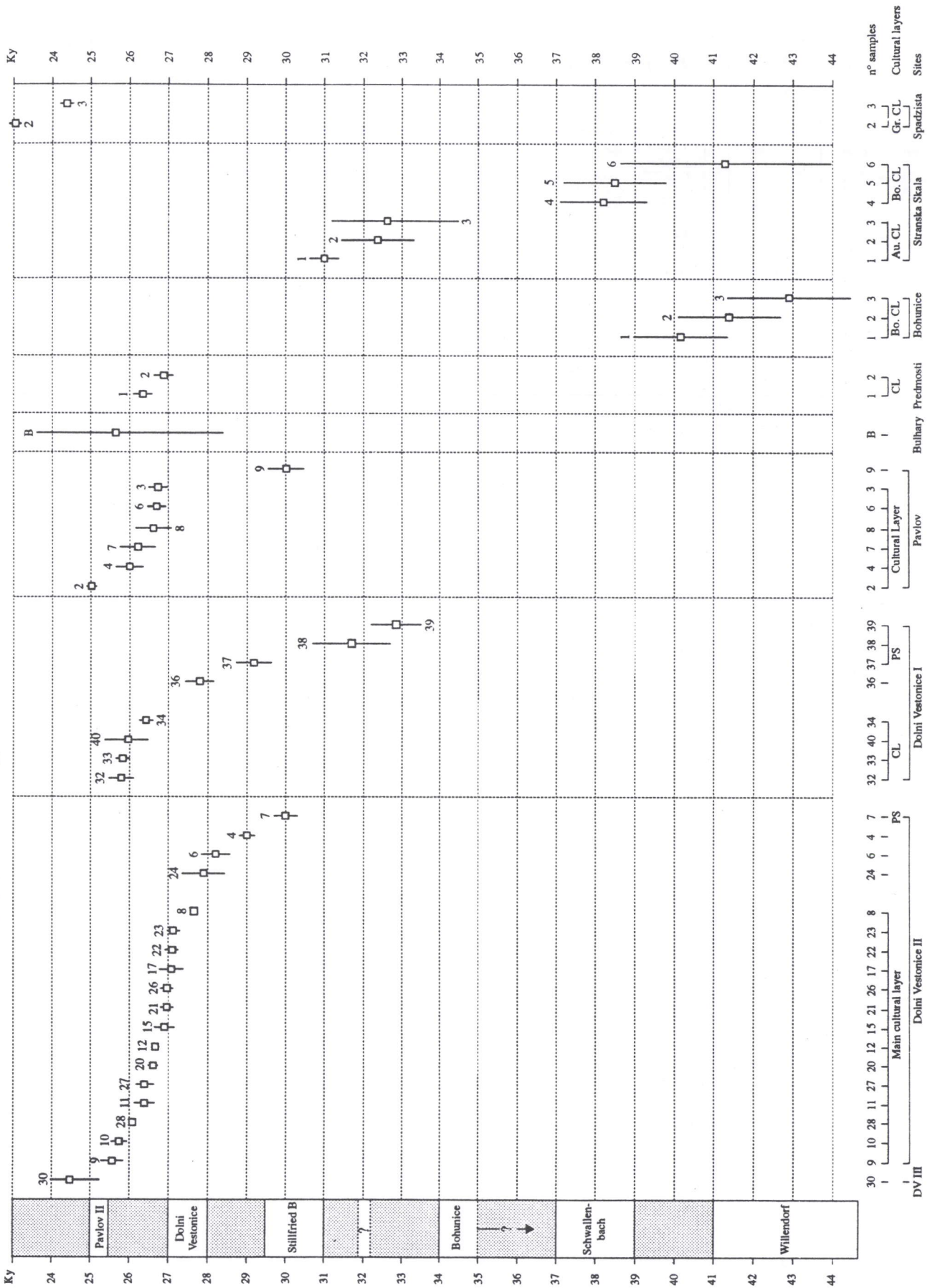


Figure 7 : Central Europe; graph B, chronostratigraphy and chronology of selected sites. Legend, PS: paleosol, CL: cultural layer, Bo: Bohunician, Au: Aurignacian, Gr: Gravettian.

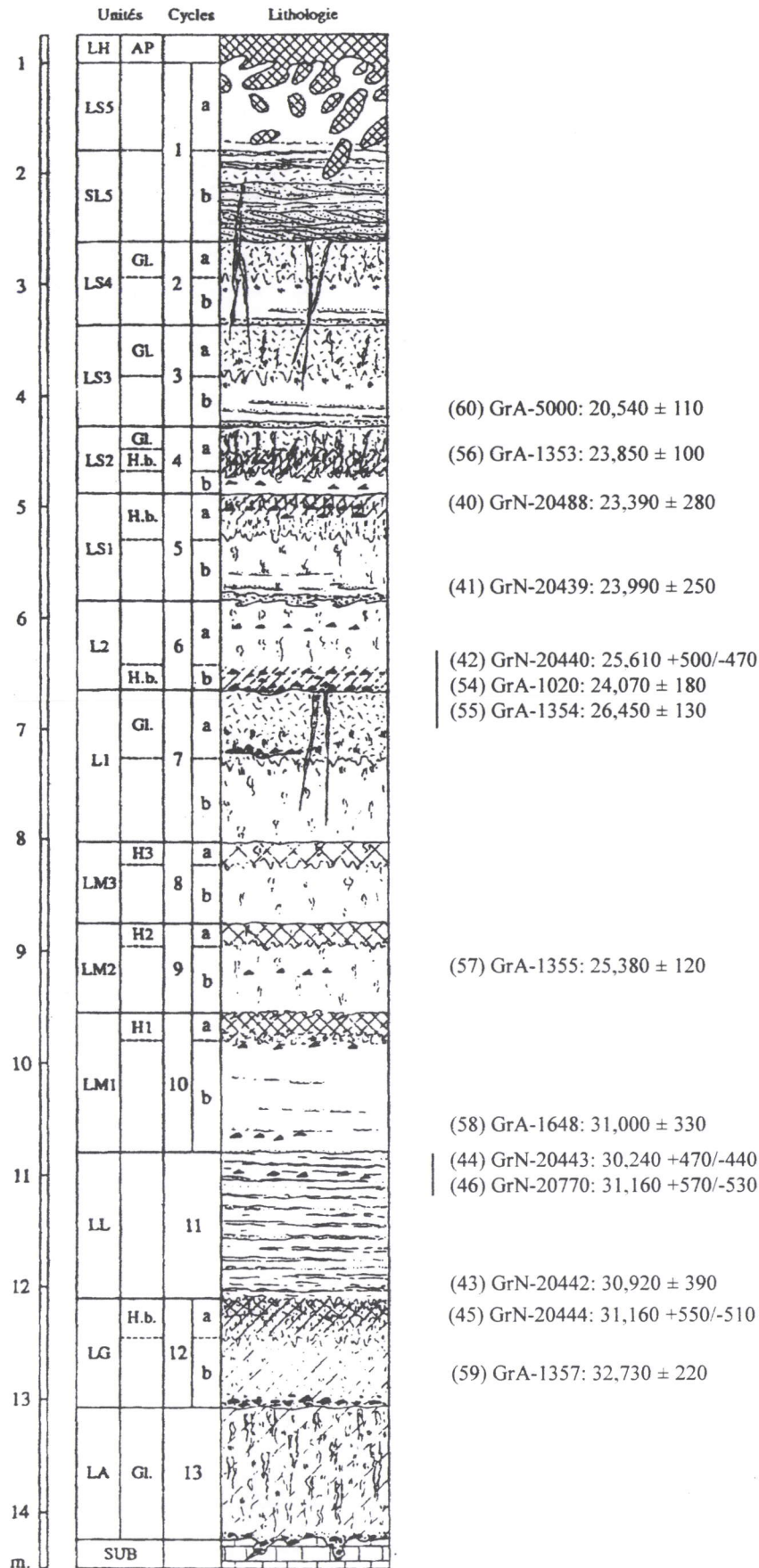


Figure 8: Mitoc Malu Galben; stratigraphical origin of the Sc-004 dates and numbers of the dates (n°) in the graphs

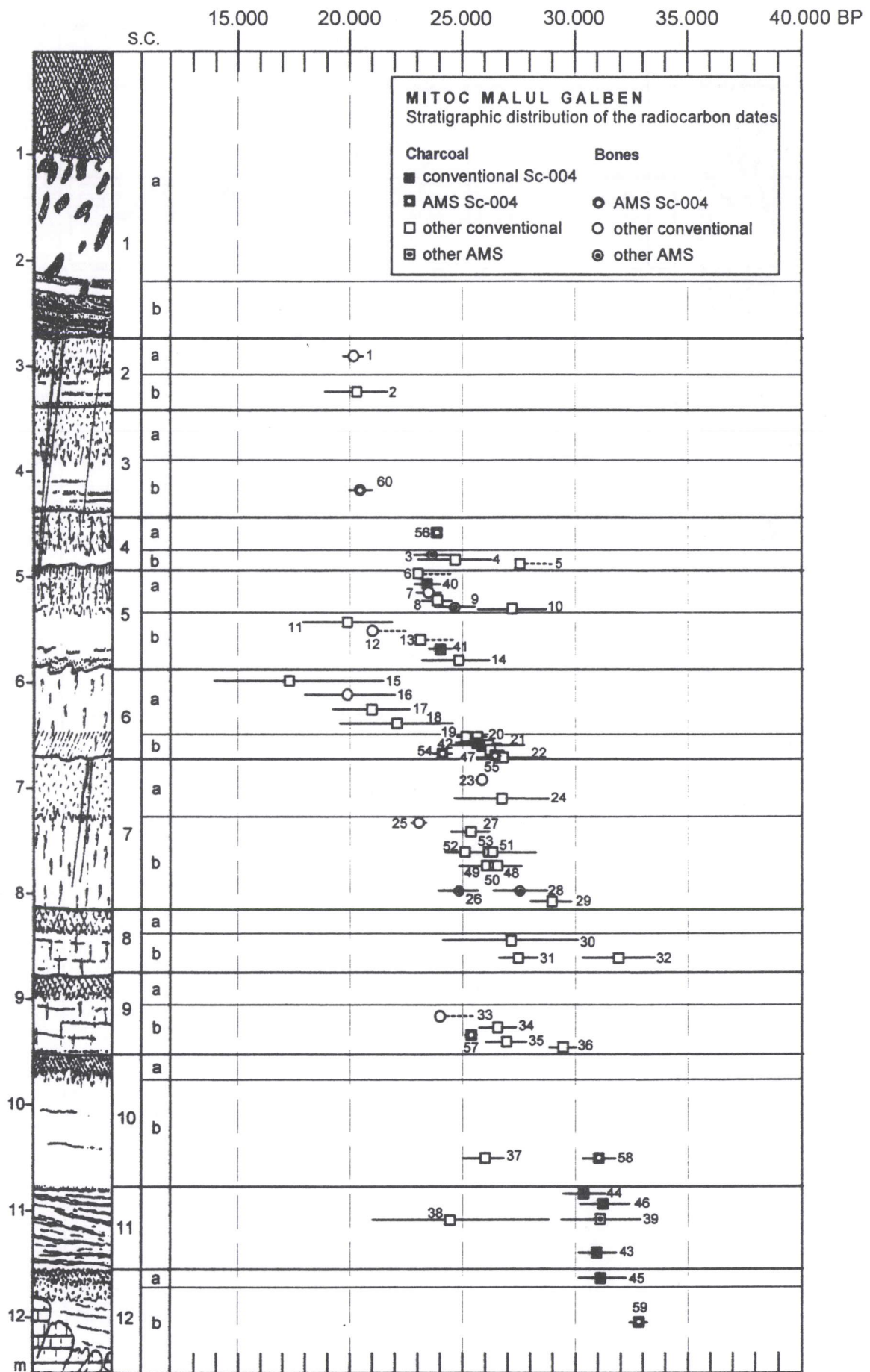


Figure 9 : Mitoc Malu Galben; graph A 1, stratigraphic distribution of the whole dates.

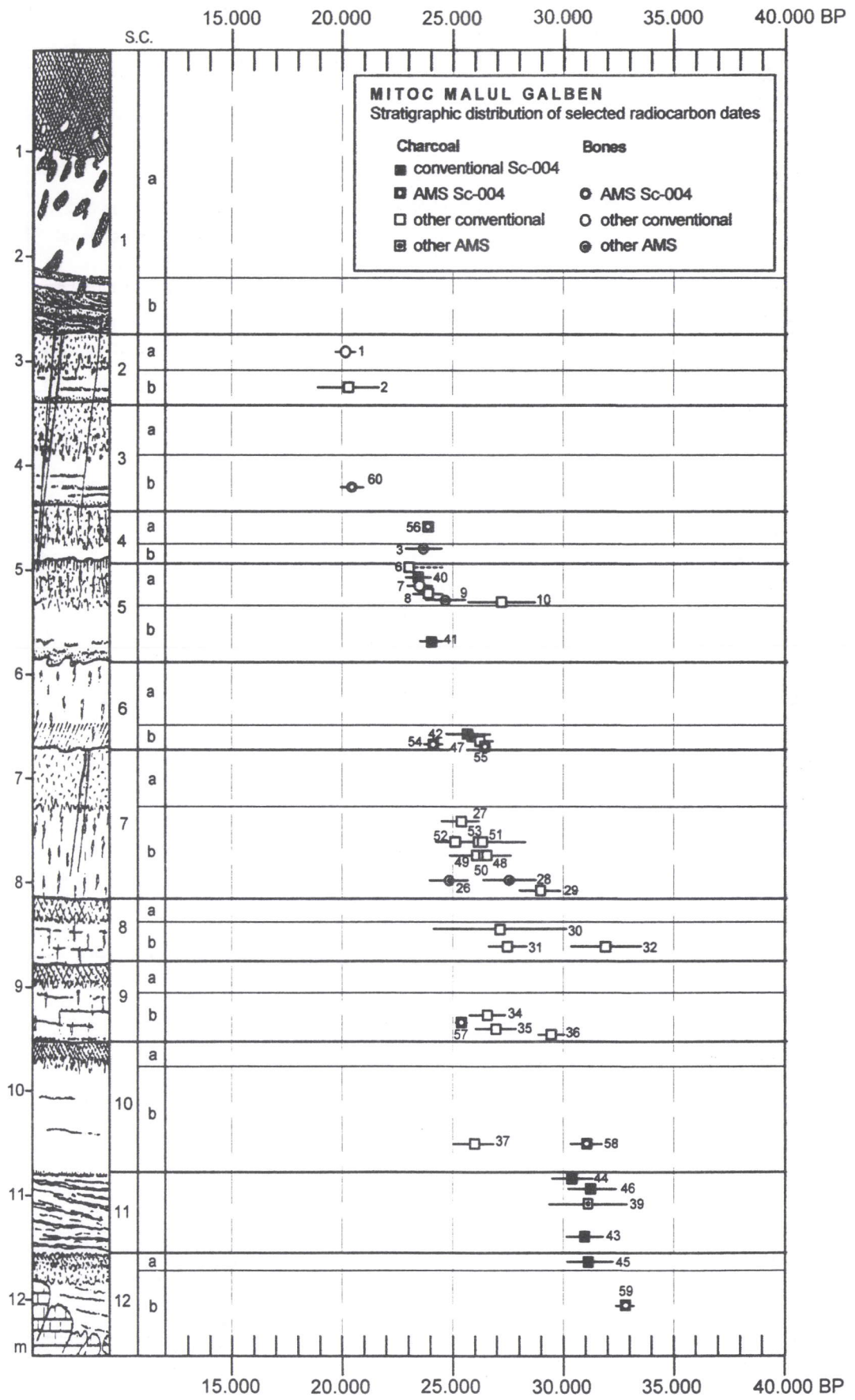


Figure 10 : Mitoc Malu Galben; graph A 2, stratigraphic distribution of the selected dates.

MITOC MALU GALBEN : chronostratigraphy and chronology

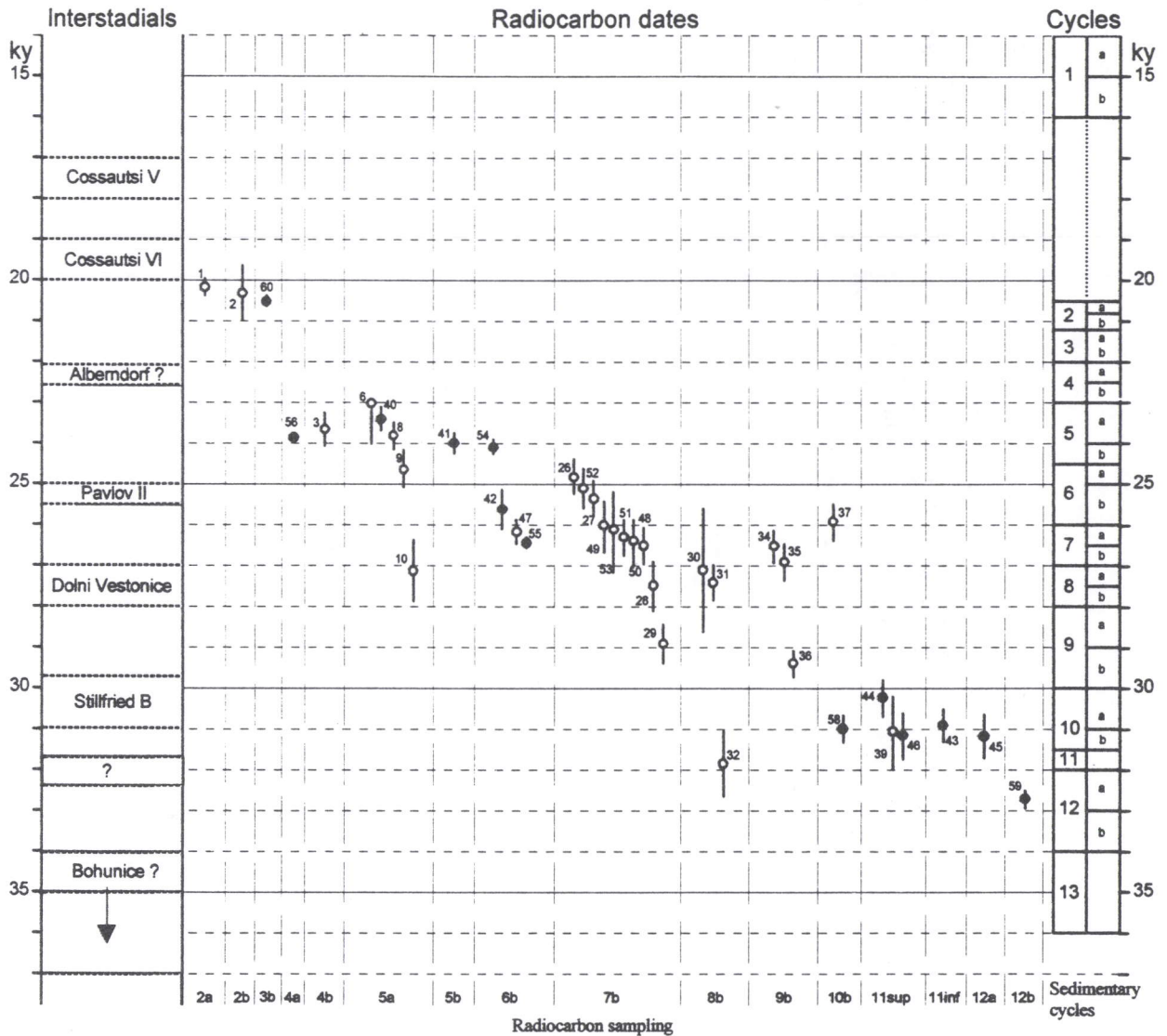


Figure 11 : Mitoc Malu Galben; graph B, chronostratigraphy and chronology of the site. The central column gives the chronological distribution of the ^{14}C dates by sedimentary cycle and by cultural layer. Symbols: ● Sc-004/GrN & GrA dates; ○ other previous dates. Right side: local chronostratigraphy; left side: chronostratigraphy for Central Europe. Both left and right sides are interpretative.

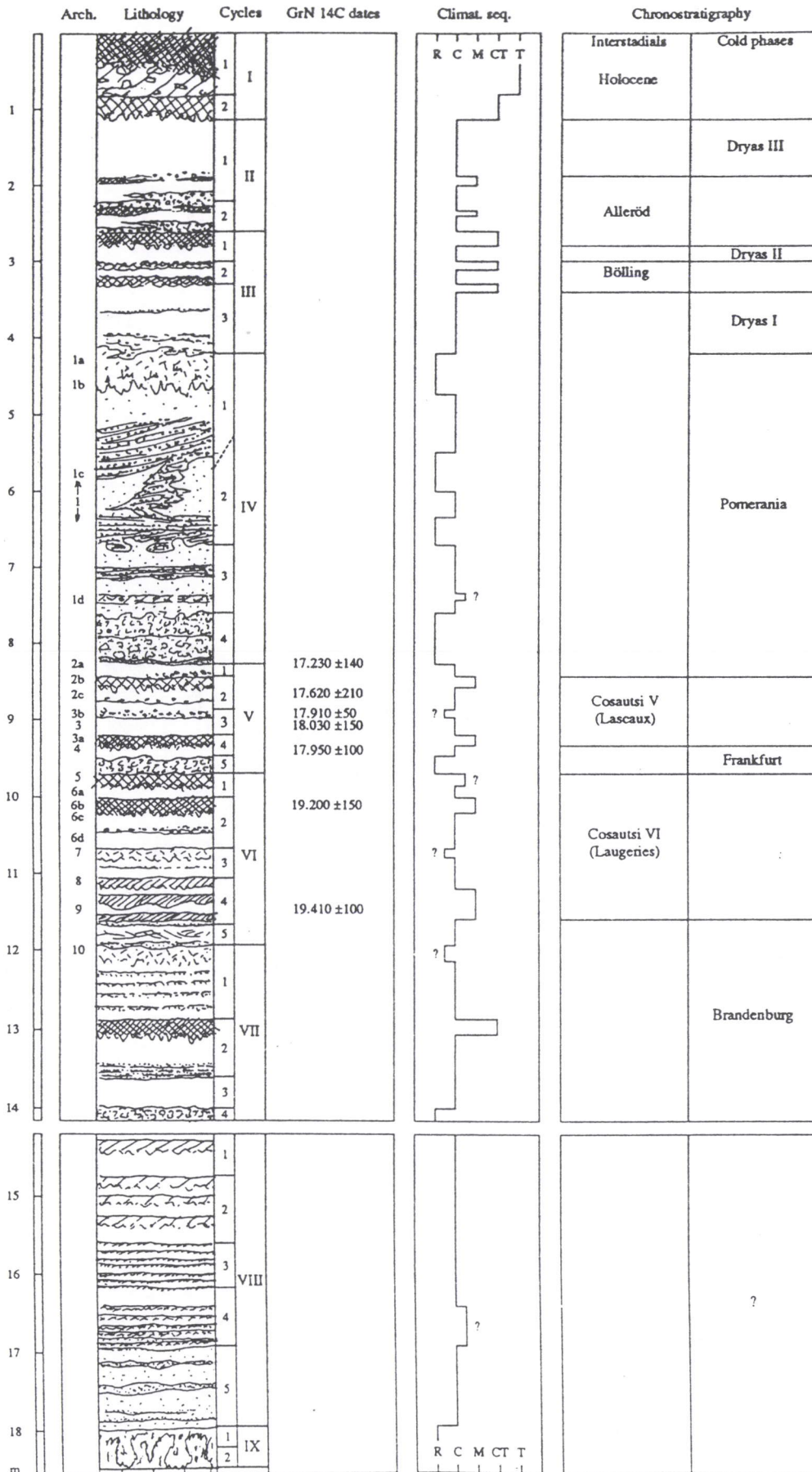


Figure 12 : Cosautsi; stratigraphic column, radiocarbon dates and palaeoclimatic interpretation (R : rigorous; C : cold; M : cold medium; CT : cold temperate; T : temperate).

COSAUTSI : Chronostratigraphy and chronology

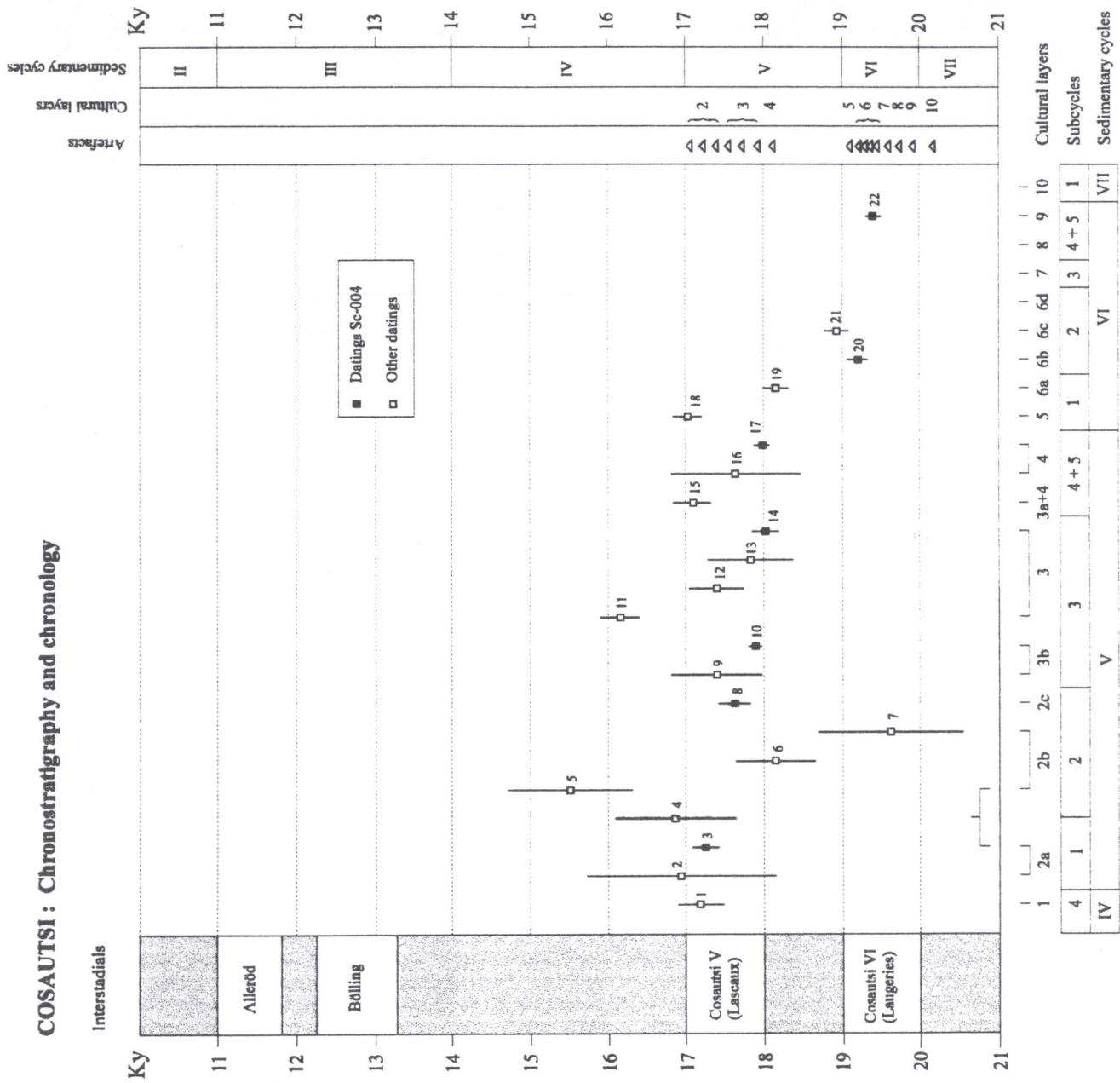


Figure 13 : Cosautsi; graph B, chronostratigraphy and chronology of the site. The central column gives the chronological distribution of the ¹⁴C dates by sedimentary cycle and by cultural layer. Symbols: ■ Sc-004/GrN dates; □ other previous dates. Right side: local chronostratigraphy; left side: chronostratigraphy for Central Europe. Both left and right sides are interpretative.

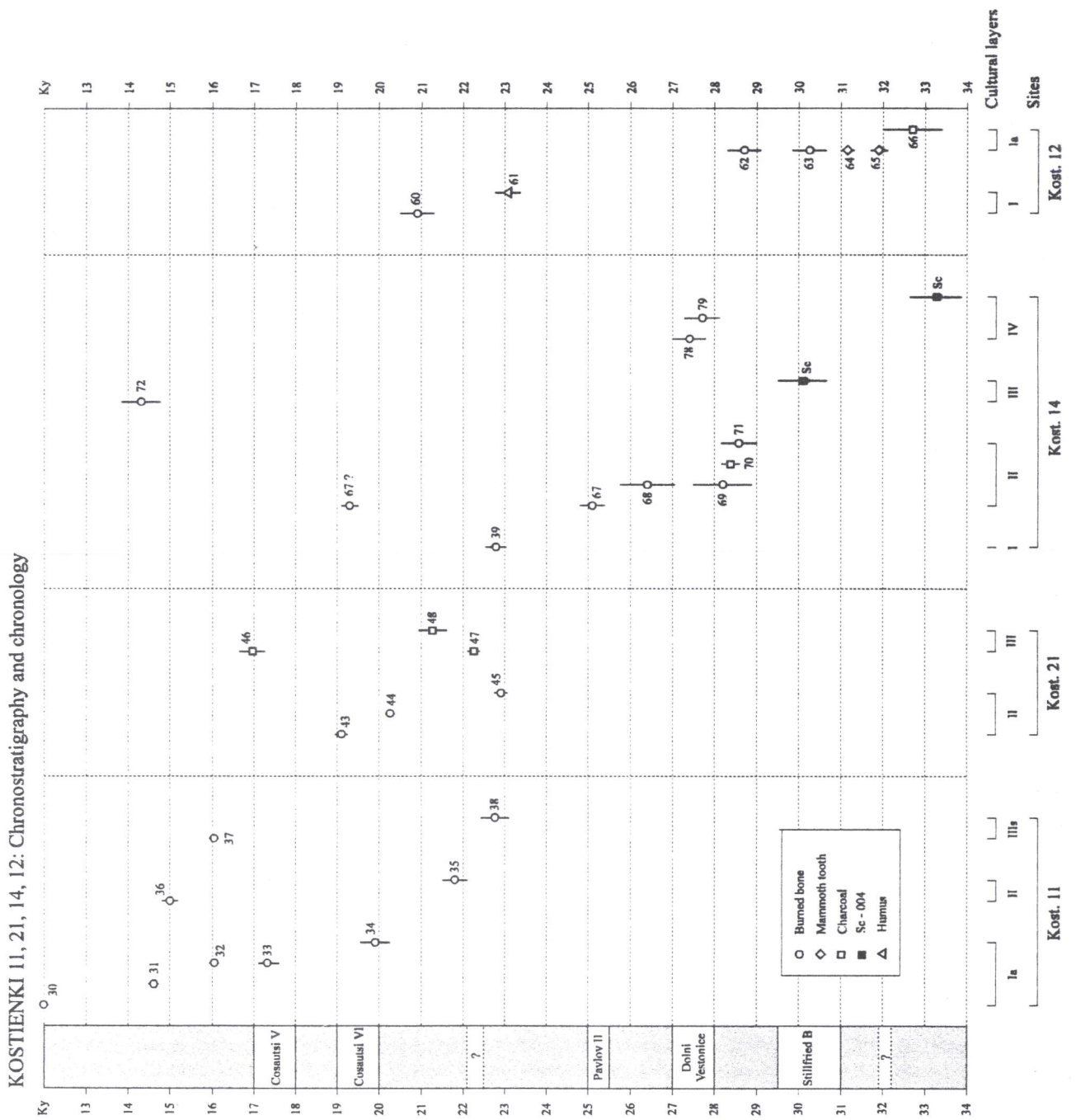


Figure 14 : Kostienki 11, 21, 14 & 12; graph B, chronostratigraphy and chronology of the sites. The central column gives the chronological distribution of the ^{14}C dates by cultural layer. Left side: chronostratigraphy for Central Europe. The left side is interpretative.

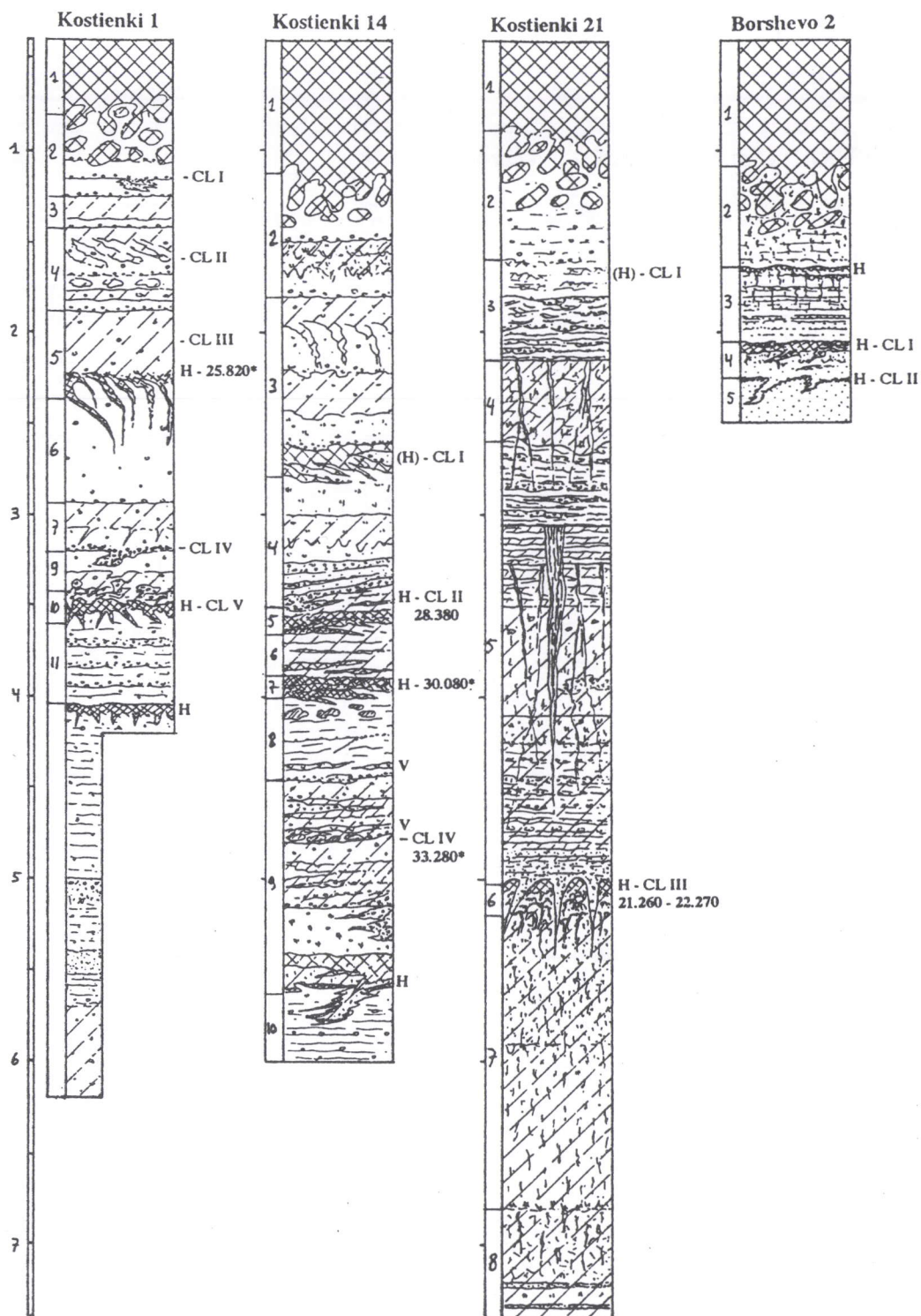


Figure 15 : Kostienki and Borshevo; stratigraphic columns of the sections studied in the frame of the Sc-004 project. Legend, CL: cultural layer; V: volcanic ash; H: humic horizon; depth in m.

KOSTIENKI 1: Chronostratigraphy and chronology

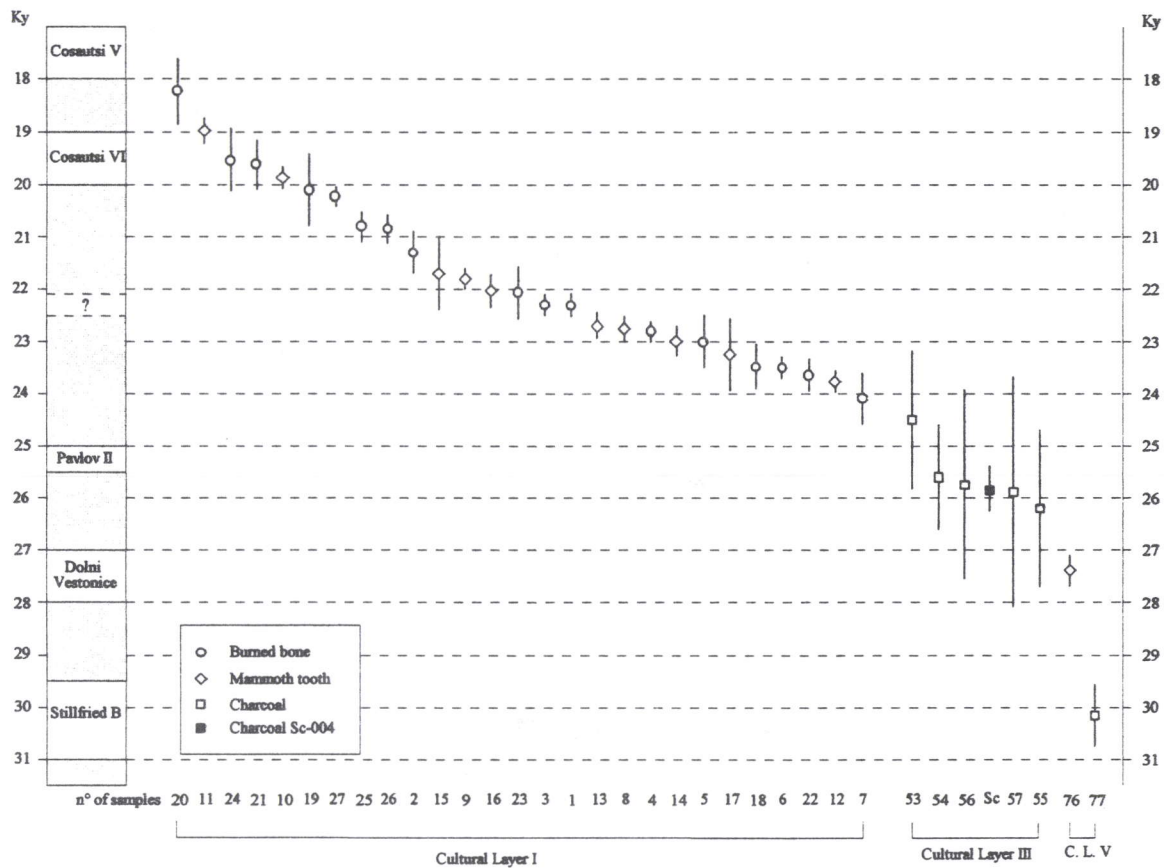
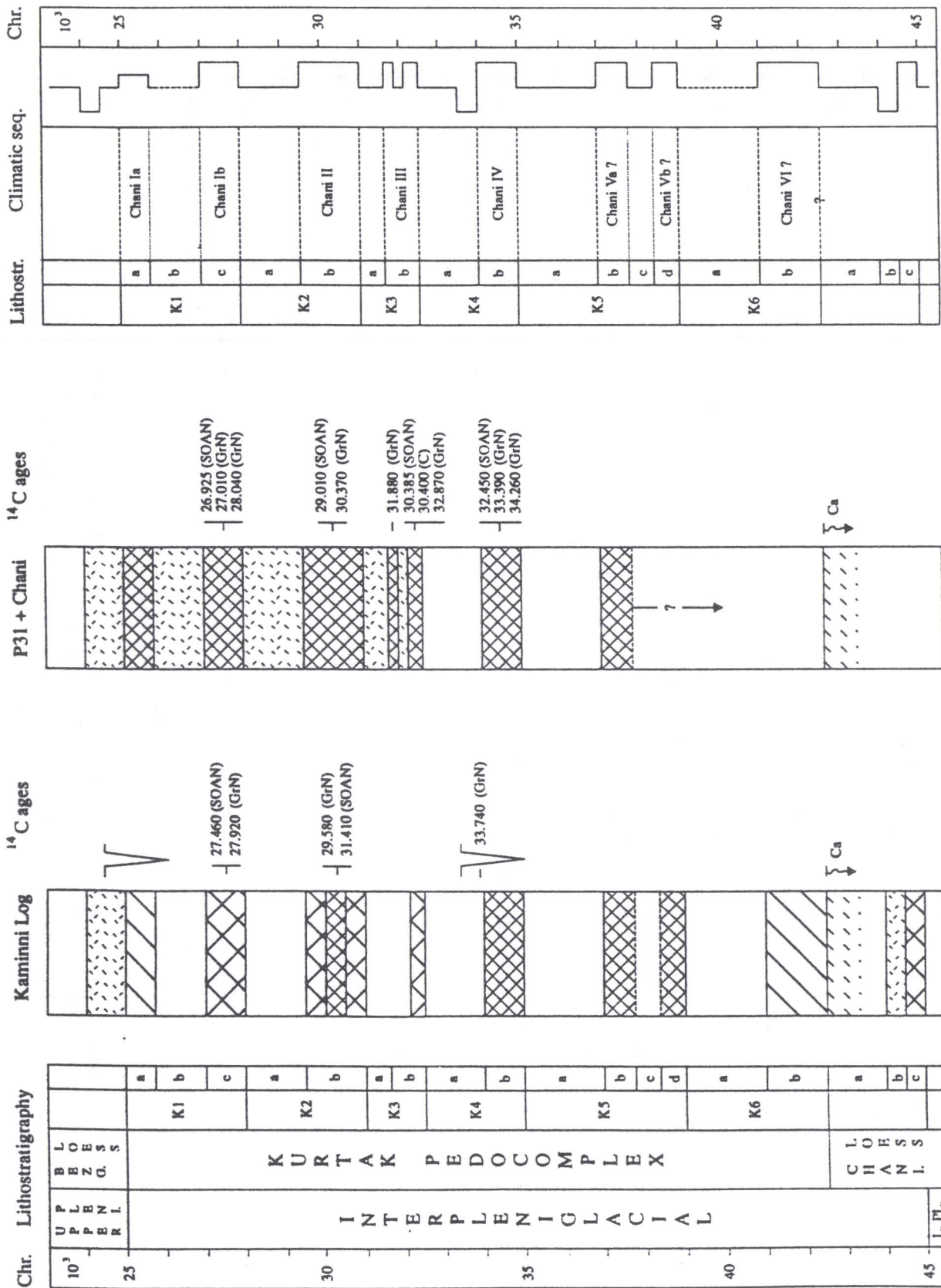


Figure 16 : Kostienki 1; graph B, chronostratigraphy and chronology of the sites. The central column gives the chronological distribution of the ^{14}C dates by cultural layer. The left side is interpretative.



P. Haesaerts; F. Dambon; N. Drozdov; V. Tcheka; 95.

Figure 17: Kurtak; chronostratigraphy and chronology of the Kurtak Pedocomplex.

KURIAK : Chronostratigraphy and chronology

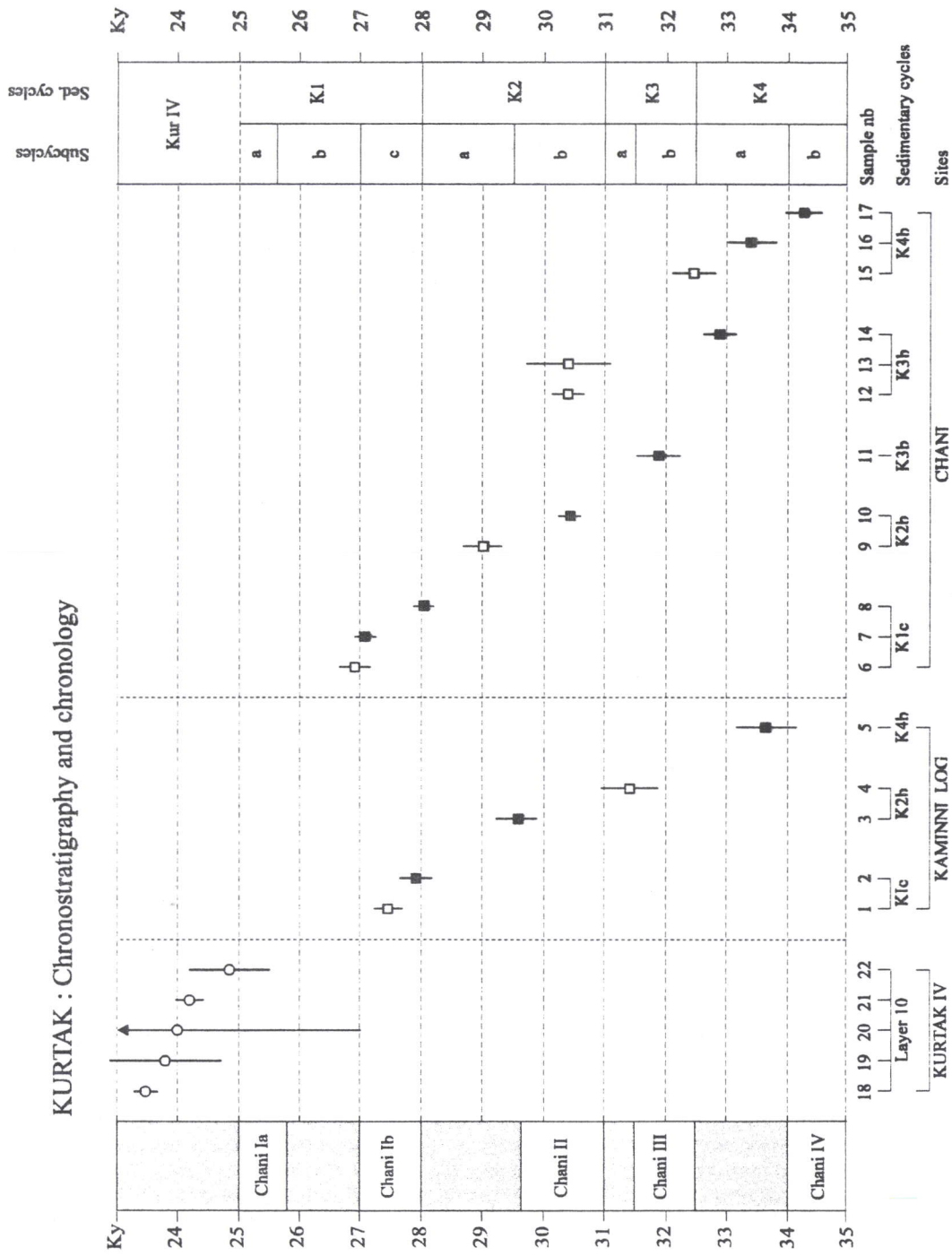


Figure 18 : Kurtak; graph B, chronostratigraphy and chronology of the sites. The central column gives the chronological distribution of the ^{14}C dates by sedimentary cycle. Symbols, ■ new Sc-004/GrN dates; □: other previous dates. Right side: local chronostratigraphy; left side: chronostratigraphy for Siberia. The left and right sides are interpretative.

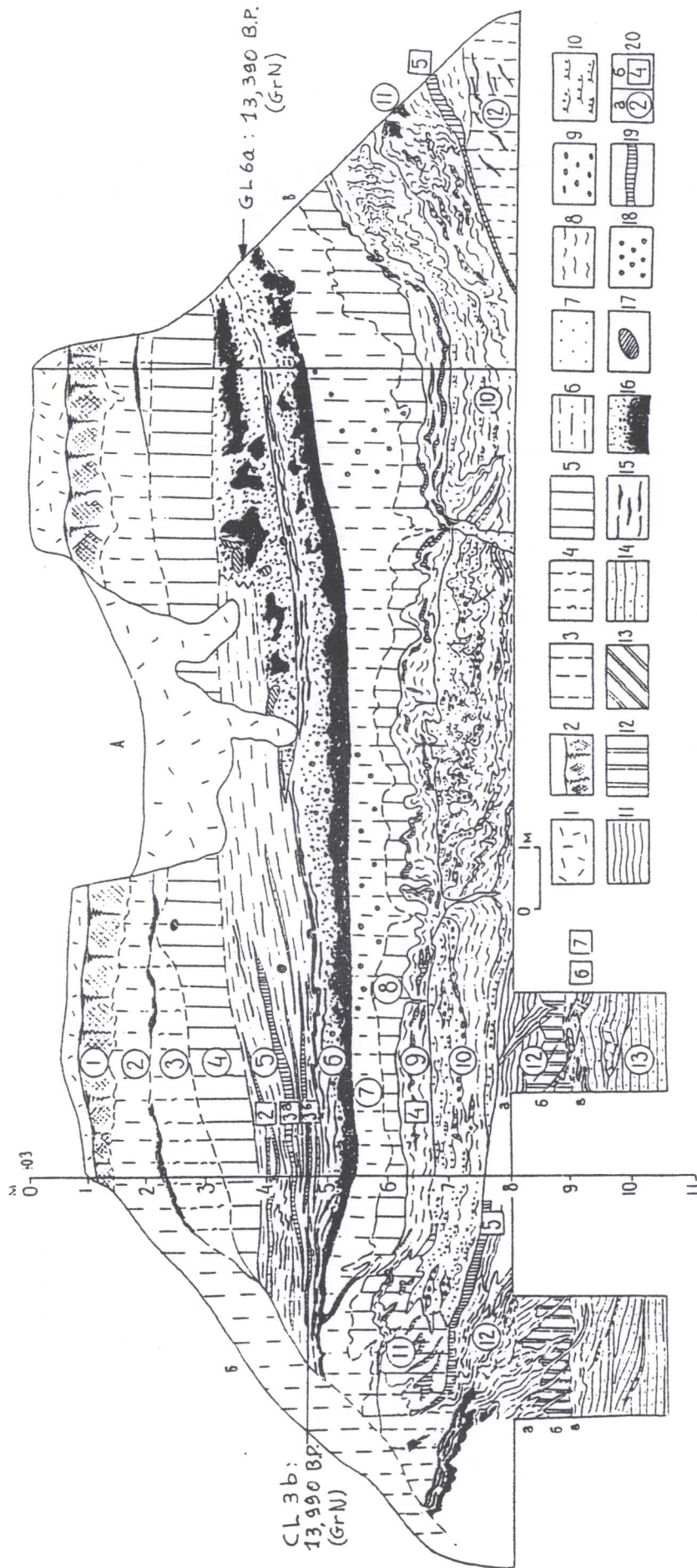


Figure 19 : Afontova Gora; stratigraphic record of station II (drawing V. Tcheka, 1993). Graphic symbols; 1 : refill; 2 : present-day soil; 3 and 4 : sandy loess; 5 : light greyish loess; 6 : stratified sandy loess; 7 : sand; 8 : laminated loam; 9 : calcic concretions; 10 and 11 : laminated sandy loess; 12 : brownish loam; 13 : reworked brownish loam; 14 : fluvial sand; 15 : humic stripes; 16 : humiferous soil horizon; 17 : krotovina; 18 : gravels; 19 : archaeological layers; 20a: numerotation of the geological layers; 20b : numerotation of the archaeological layers.

AFONTOVA GORA: Chronostratigraphy and chronology

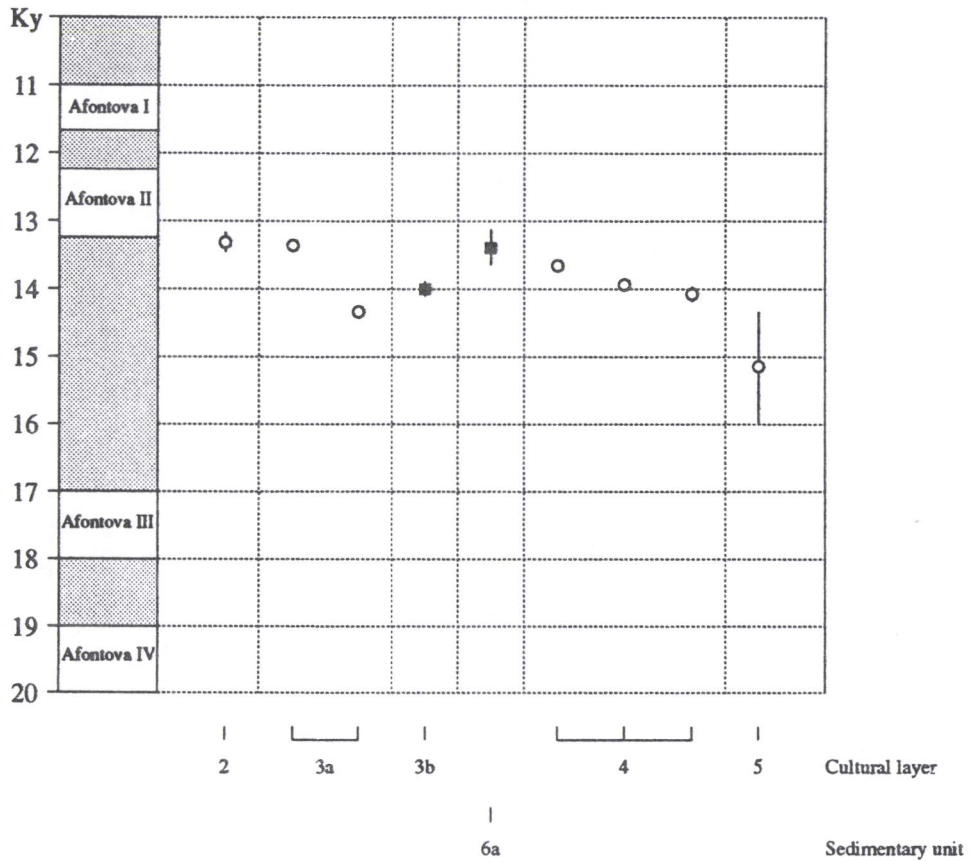


Figure 20 : Afontova Gora; graph B, chronostratigraphy and chronology of the sites. The central column gives the chronological distribution of the ^{14}C dates by cultural layer and by sedimentary unit. Symbols, black squares: new Sc-004/GrN dates on charcoal; white circles: previous dates on bones. Left side: chronostratigraphy for Siberia. The left side is interpretative.

Figure 21 : Distribution of the palaeolithic assemblages and ^{14}C dates with regard to the chronostratigraphic sequences of Central Europe (left) and Central Siberia (right). Shortenings and symbols. Climatic sequences; R : rigorous; C : cold; M : cold medium; CT : colt temperate; T : temperate. Archaeological assemblages; Δ : Gravettian (Gr.); \blacktriangle : Aurignacian (Au.); \circ : Early Upper Palaeolithic (E.U.P.); \blacksquare : Mousterian (M.P.); x : geological sample. Sites. Austria; Gr. : Grubgraben; Will. : Willendorf; Schw. : Schwallenbach; Strat. : Stratzing. Czechia + Poland; Sp.B. : Spadzista B; Pav. : Pavlov; D.V. : Dolni Vestonice; D.V.br. : Dolni Vestonice brickyard; D.V.A. : Dolni Vestonice, station A; Str.SK. : Stranska Skala; Boh. : Bohunice. East Carpathians; Cos. : Cosautsi; Mit. : Mitoc Malu Galben; Rip. : Ripiceni. Central Russia; K. : Kostienki; Khot. : Khotylevo. Central Siberia; Af. : Afontova Gora; List. : Listvenka; Kur. : Kurtak; K.B. : Kara Bom. Radiocarbon datings: (*) Groningen dates of Sc-004 project, 20.000: Groningen dates; (20.000): dates from other laboratories.

